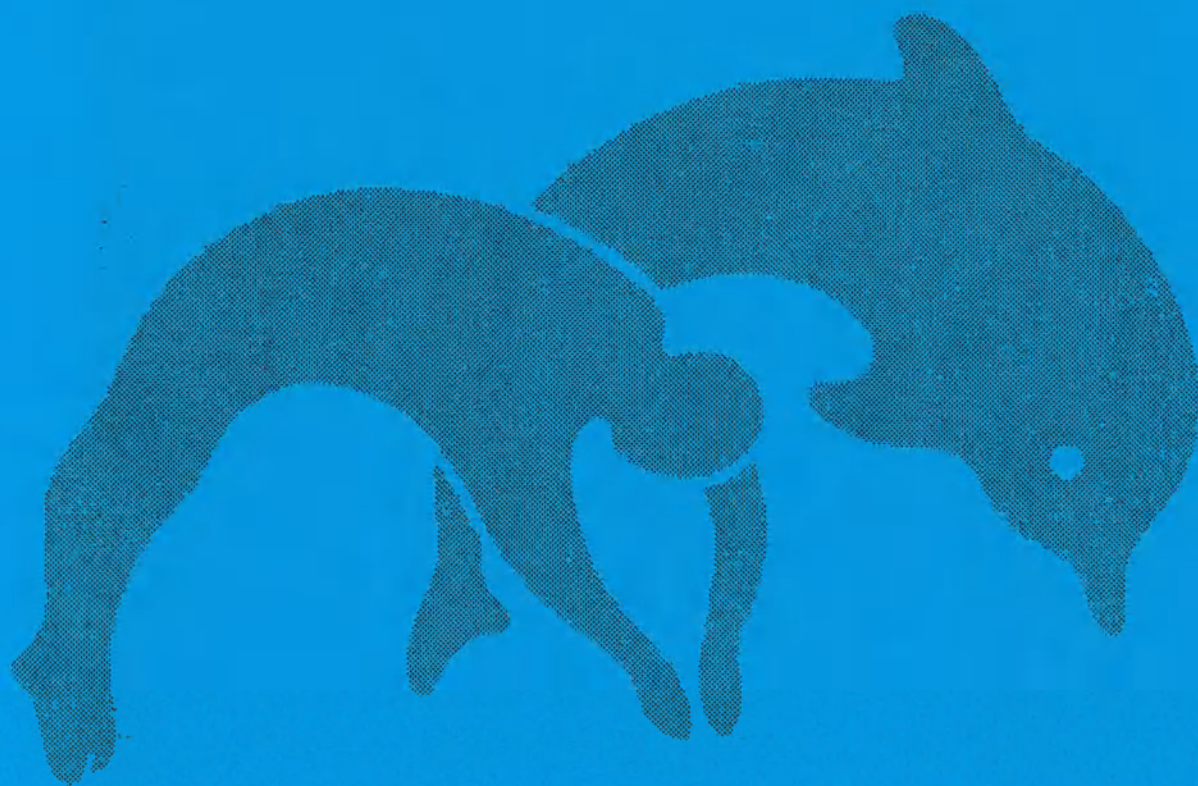


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Oostende - Belgium

**Marine Conservation Society**

# FACTSHEETS



26319

**MARINE HABITATS**



# ROCKY SHORES

RJH/01/00

ROCKY SHORES ARE SUPERB PLACES FOR EXPLORATION - THERE IS SO MUCH TO SEE. ROCKPOOLS PROVIDE A GLIMPSE INTO THE UNDERWATER WORLD, WHILE LEDGES, CREVICES AND OVERHANGS PROVIDE A HOST OF SUITABLE SURFACES FOR ATTACHMENT AND SHELTER. AS THE TIDE LOWERS ROCKPOOLS WILL FORM AS SELF - CONTAINED HABITATS, BUT AS THE TIDE RETURNS THEY BECOME PART OF THE SEA ONCE MORE.



Reg Charity No 1004005

## Factors affecting the ecology of rocky shores

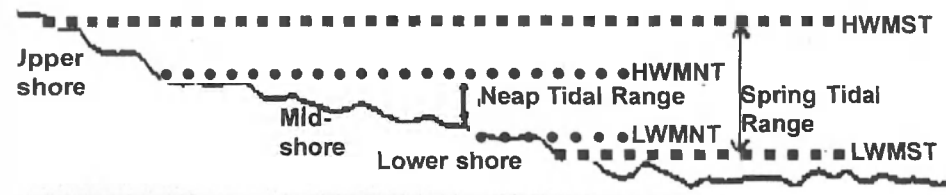
A number of factors affect species and communities found on rocky shores:

### Tides

The daily rhythm plus monthly changes between spring and neap tides ensure a constantly changing environment. Those organisms which live on bare rock uncovered by tides and rockpools must tolerate frosts, fresh airwater, prolonged sunshine and desiccating winds.

LWMST - low water mark spring tide  
HWMST - high water mark spring tide  
LWMNT - low water mark neap tide  
HWMNT - high water mark neap tide

### Tidal Zones on a Shore



### Exposure

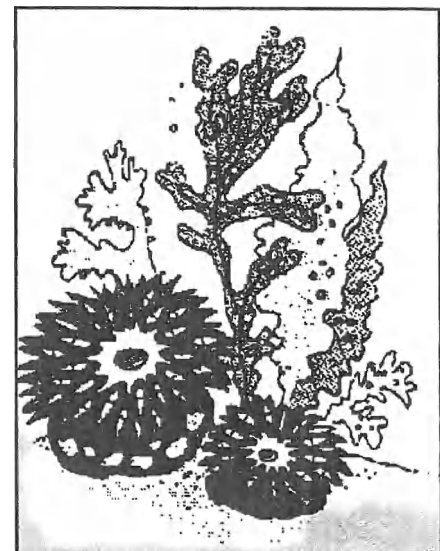
A shore exposed to strong wind, waves and swell from the open ocean will support different communities of plants and animals compared with a shore in a sheltered bay or estuary. The inhabitants have to adapt to many different conditions; plants that are strongly attached, smooth and low growing will survive best on exposed shores, whereas the more delicate plants can only survive in sheltered areas. The slope of a shore also affects exposure; rockpools at different heights on the shore will have different inhabitants.

### Dimensions and Shape of Rocks and Rockpools

The rocky substrate determines what sort of rockpools, crevices and ledges form, and physical conditions within rockpools may fluctuate widely depending on their shape and size. For example, a shallow pool along the upper shore will experience great changes in salinity, temperature and dissolved oxygen content, and may be isolated from the sea for long periods (e.g. during neap tides and prolonged calm weather). Nearer to the low water mark large, deep pools will only be exposed for very short periods, and conditions will be more like those of the sub-littoral zone (the area beyond low water that is always submerged). In the middle of the shore, rockpools will be regularly covered and uncovered by the tide, allowing for communities of specialist rocky shore inhabitants.

## How do rockpools form?

Along stretches of coast where rock is exposed within the intertidal zone, the constant force of the sea gradually wears away the rock surface. Attack is greatest where the rock is softer and weaker, and this eventually produces an uneven surface full of depressions, cracks and crevices. Rock fragments and particles of sand, broken from the surface by waves, may become trapped in the depressions and crevices. These act like scouring pads as they are rolled back and forth with water movement. This action causes the holes to become bigger and bigger over time so that when the tide ebbs, the holes remain full of seawater. This provides a home for a whole host of plants and animals, though they must get used to some regular and extreme changes in conditions.



## Physical conditions in rockpools

### Temperature

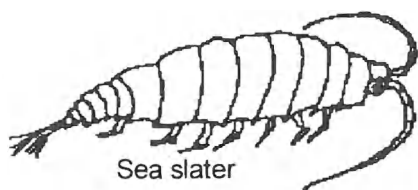
When exposed, the temperature of water in rockpools becomes affected by air temperature. A very hot sun will heat the water in the pool. If the pool is on the upper shore the water can become very warm which in turn will affect the amount of soluble gases available in the water for inhabitants. In hot summers, the shallowest pools on the upper shore may dry out whilst in winter, pools may become colder than the sea and freeze over. Again, it is the pools on the upper shore which are most affected.

### Salinity

Evaporation from rockpools will increase salinity, whilst fresh water from heavy rainfall will reduce salinity. Upper shore pools are subjected to the most extreme changes. However, heavy rain into a deep pool tends to produce a layer of fresh water on top of the saline water. The most extreme fluctuations in the salinity of rockpools occur during a high tide.

### Oxygen

Oxygen levels are affected by the amount of photosynthesis and respiratory activity in the pools. On sunny days, oxygen bubbles can be seen on rockpool plants but the amount of oxygen will be reduced by the activities of the animals at night. The processes of photosynthesis and respiration affect the levels of carbon dioxide and nutrients within the pool and these will also change during the



Sea slater

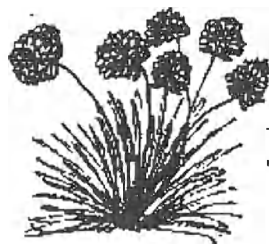
day and night. When rockpools are submerged by the incoming tide, the variables change once again, although deep pools are less affected by changes.

## Zonation on Rocky Shores

As a result of the variations in conditions over the shore, all shores can be divided into zones displaying specific characteristics and communities that are also affected by wave action, availability of light, desiccation due to exposure, substrate (type of rock surface), aspect and biotic factors (competition and grazing).

### The Splash Zone

This Zone is only occasionally inundated by seawater, and conditions are therefore extremely variable over time, making it a harsh place for organisms to survive. Frequently affected by salt spray and strong winds, most plants and animals can be found in the relative shelter of numerous nooks and crannies amongst the rocks and on cliff faces.



Thrift or "sea pink"

Plants include rock samphire, thrift and sea campion plus encrusting organisms such as black, yellow and green lichens. Creeping plant cover is best adapted to these inhospitable sites, and the sea campion is a common plant of this zone because its low-growing form resists the effects of strong winds whilst strong roots ensure a firm anchorage. Thrift also takes on a compact form to resist strong winds whilst its narrow, needle-like leaves prevent the plant from drying out too much in the wind. Sea campion has a waxy surface to its leaves to prevent desiccation.

Animals of the splash zone tend to be scavengers that hide beneath debris or are well adapted to cope with long dry periods. The sea slater is common within this zone but is rarely seen because it is a nocturnal

(night-time) feeder that hides away from predators during the day. Other animals to look for amongst the debris are the springtail, bristletail and the periwinkle.

### Upper shore

Here organisms must be extremely well adapted to the vigorous conditions of exposure, wave activity and wide fluctuations in salinity and temperature due to the rhythmic cycle of the tides. In upper shore rockpools salinity levels can alternate between 5% and 30%, and temperatures range from very high to freezing.

Plants of the upper shore must be very tolerant to temperature and salinity changes. The most abundant seaweed of this zone is the channelled wrack which has adapted to long periods of exposure by curling the edges of its fronds to help trap moisture. The upper limits of algal species will also be determined by grazing activity of animals such as limpets.

The few animal species that are



Limpets



adapted to live within this zone tend to have a protective outer shell or are permanently attached to the rock surface. The acorn barnacle, for example, is permanently cemented to the rock surface and can close its "trap door" when exposed. When submerged, the trap door is opened for the barnacle to feed. Limpets remain firmly attached to a rock surface when the tide is out; when submerged the limpet becomes active, leaving its "home spot" to feed. It feeds on tiny algae rasping them off the rock with its nail-file tongue (radula). Limpets are very efficient at keeping rock surfaces clean and if they are removed from a shore the area soon becomes covered in a prolific growth of algae.

ce it has finished feeding, the  
 et returns to its home spot to  
 ome firmly attached in order to  
 id predation and desiccation  
 an the tide recedes. The shore  
 o is able to control its own salt  
 els so can live quite happily  
 er the stressful conditions of the  
 er shore.



Common shore crab

### Upper shore

s zone displays a greater  
 iversity of species because it is an  
 a that does not suffer such long  
 ods of exposure and variation  
 hysical factors as the upper  
 re. Again, many of the animals  
 e shells to protect themselves  
 inst abrasion, desiccation and  
 lation when they are exposed  
 he shore. Like many of the upper  
 re animals they seek shelter  
 n the tide is out. Damp crevices,  
 rhangs and underneath  
 weeds are the best places to  
 for animals. Bladder wrack,  
 ated wrack and knotted wrack  
 common in this zone and may  
 ide a very dense cover to the  
 s and within the pools. Because  
 onditions within and beneath the  
 weeds are very damp, a closer  
 ection will reveal many animals  
 can often be seen feeding over  
 seaweed. Look for wandering  
 inkles, dogwhelks and limpets.

Attached animals include mussels,  
 various types of barnacle and the  
 beadlet anemone. This anemone is  
 easily identified because it looks like  
 a blob of red or greeny-brown jelly  
 when exposed (it retracts its  
 tentacles). Beadlet anemones within  
 rockpools can be seen with their  
 stinging tentacles opened out and if  
 you are patient you may be lucky  
 enough to see them feeding.

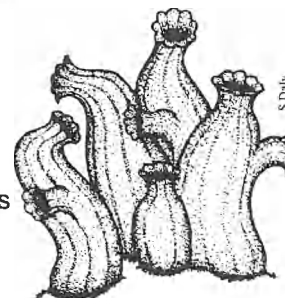
In some pools the rocks are covered  
 in calcified, pink seaweed called  
 coralline algae, which cannot  
 withstand drying out so depend on  
 the pools for survival. They leave  
 white "skeletons" behind when  
 dead.

### Lower shore

Animals:

This zone is the most prolific  
 because the rocks and pools are  
 exposed and cut off from the sea  
 for only short periods, allowing  
 many more soft-bodied animals to  
 survive. Rockpools in this zone offer  
 more stable conditions of  
 temperature and salinity. If the pool  
 is deep, many larger animals such  
 as crabs and lobsters may be hiding  
 amongst rocks and crevices, whilst  
 fish such as wrasse which have  
 been trapped within the pool feed  
 around the edges. Starfish,  
 brittlestars and anemones  
 (especially the snakelocks  
 anemone, which is unable to retract  
 its tentacles and can therefore only  
 survive in areas that are constantly  
 submerged) can be seen. Some fish  
 have adapted to rockpool life and are

able to survive in these more  
 turbulent areas. The lumpsucker  
 can grip to rock surfaces by a  
 powerful sucker which it has on the  
 underside of its body. Butterfish are  
 rockpool inhabitants but they can  
 also live underneath boulders on the  
 lower shore. Also look for rockling,  
 pipe fish, shanny, gobies and sea  
 scorpion. Encrusting species  
 include sponges, bryozoans and  
 sea squirts.



Lightbulb sea squirts

Seaweeds:

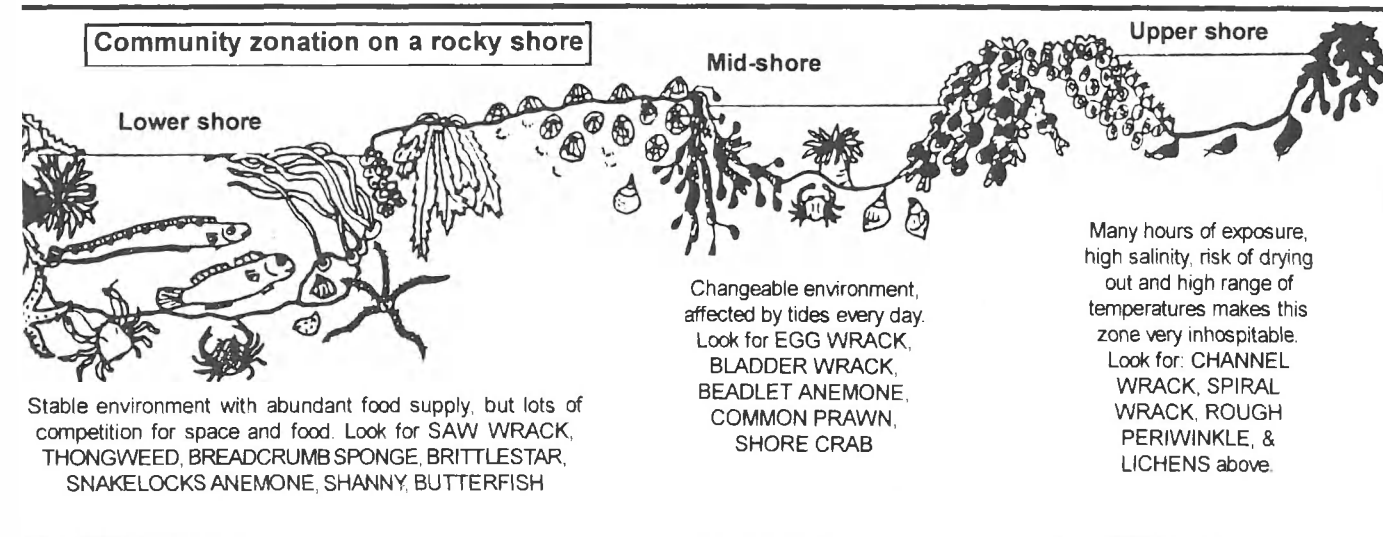
These include familiar tangle weed,  
 sugar kelp and thongweed, and  
 many red-pigmented species.  
 However, along some shores an  
 invader dominates. Japanese weed  
 (*Sargassum muticum*) is a prolific  
 grower and was first found on British  
 shores in 1972. Nobody is sure how



*Sargassum muticum*

it got here from the Pacific, but it  
 probably "hitched" on the hull of a  
 ship. It is now very widespread along  
 the shores of the English Channel  
 and Irish Sea.

### Community zonation on a rocky shore



# Major threats

## Pollution

There are many sources and types of pollution that have an impact on the rocky shore:

## Sewage and Sewage Related Debris

The discharge of raw sewage to beaches and inshore waters is still widespread in Britain. Such discharges contain human excreta, domestic cleaning agents, industrial waste, oil and run-off from roads. In addition, there are often large quantities of plastic and metal objects. Not only is sewage and sewage related debris unpleasant to see on a beach but it may also present a health risk to bathers. Shellfish, such as mussels which are filter feeders may also become contaminated, and if eaten by humans may cause severe illness. Plastic and metal items such as bags and ring-pulls are a danger to wildlife through entanglement and ingestion.

## Oil

Oil is often found on rocky shores, coating rocks or as tar balls that may become stuck in crevices and holes. Most of this oil has come from the deliberate washing of tanks out at sea, or has entered the sea from municipal waste water pipes - perhaps surprisingly, only 3% of oil

pollution comes from major shipping accidents involving oil tankers despite their obvious effects.

## Industrial Pollution

Little is known about the ecological effects of numerous toxic and potentially toxic chemicals. However, the bioaccumulation of pollutants, often far from the point of discharge, is well documented. Some chemicals have been used deliberately in the marine environment; TBT which since 1987 has been banned as an antifoulant on yachts less than 25m long (but is still used illegally), is known to be devastating to populations of dogwhelks and shellfish.

## Collection and Trampling

The Victorians made collection of species from the shore a very popular pastime and have probably accounted for the decline in many plants and animals. Widespread and uncontrolled collection of species for educational purposes is not necessary as it is far better to study them in their own habitat. The popularity of many shores as sites of exploration and investigation has caused problems of trampling, whilst boulder-turning can damage habitats, crush organisms and leave others open to desiccation and predation.

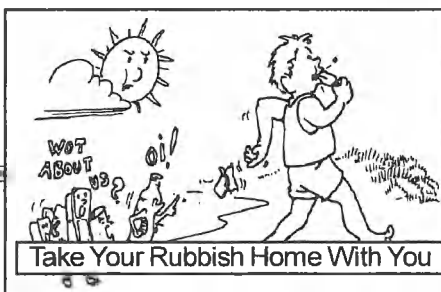
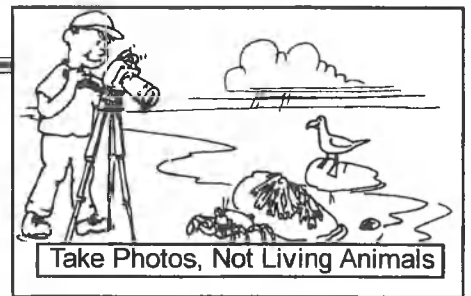
## Recreation

The beaches and inshore waters of Britain are very popular areas for recreation and the level of use in recent years has increased dramatically. The impact of recreation can be both long and short term; disturbance to wildlife is the major area of conflict especially in areas that support large numbers of seabirds and seals.

## What can YOU do?

1. Join the Marine Conservation Society and support our campaigns to protect the marine environment for wildlife and future generations.
2. Always follow the MCS Seashore Code (below), and take part in MCS projects such as our annual *Beachwatch* beach survey and clean-up campaign, or *Adopt-a-Beach*.
3. Learn more about the marine environment. MCS Sales stocks titles suitable for all ages and all levels of interest.

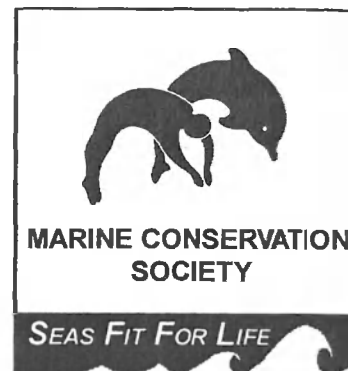
Send a large SAE for information to:  
**Marine Conservation Society**  
9 Gloucester Road  
Ross - on - Wye  
Herefordshire  
HR9 5BU  
[www.mcsuk.org](http://www.mcsuk.org)



# SANDY SHORES

RJH/01/00

IN SUMMER, MANY SANDY BEACHES ARE FAVOURED BY SUNBATHERS. BUT WHAT IS A SANDY SHORE REALLY LIKE WHEN THE SUNBATHERS HAVE GONE HOME AND THE TIDE IS RISING FAST? THE SANDY AREAS THAT WERE BEING MADE INTO SANDCASTLES JUST A FEW HOURS BEFORE ONCE AGAIN COME TO LIFE - YOU WOULD BE AMAZED AT THE VARIETY OF LIFE IN THESE SANDY SHALLOWS.



Reg Charity No 1004005

## Sand

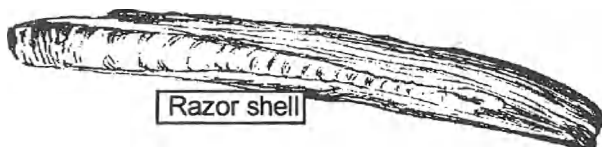
Sand, those tiny particles of rock and shell that always find their way into your sandwiches on a seaside picnic, are the product of years of erosion. The characteristics of each grain depend on the rock type it comes from. Sandy shores near coral reefs will be made up primarily of coral-derived limestone, often as a result of the way parrotfish feed. On UK beaches, it is more common to find quartzite particles, which are the toughest components in igneous, metamorphic and sedimentary rocks. While sandy beaches and seabeds may, at first glance, seem less full of life than rocky shores, they do support many organisms below their surface - this provides an extra dimension compared with hard and flat rocky floors.

The size of sand particles influences what can actually live in or in it; very coarse grains allow water to drain away quickly and so easily dry out, especially in the upper shores where a beach is exposed for many hours during the tidal cycle. Soft, fine sands mixed with even smaller sediments are perfect for burrowing worms and brittlestars to inhabit, and usually provide more stable environments as well.

## Beachcombing

### Strandline delights

In some bays, the wind and waves wash up large amounts of seaweed that have been broken away from rocky reefs offshore. Piles of organic material are a familiar sight along the strandline, especially after the first storms of Autumn and during Spring when kelp sheds its fronds. Rotting seaweed on the shore provides rich



Razor shell

pickings for a multitude of wildlife. Sandhoppers, kelp flies, beetles, seabirds and many other scavengers can all find something tasty. Next time you see piles of rotting seaweed on the shore don't complain that it is unsightly and smelly, but marvel at the variety of life it supports on a seemingly desolate beach. Seaweed is natural, unlike the large quantities of plastic bottles, aerosol canisters, plastic rope and netting that can also often be seen along the strandline.

A beachcombing expedition along the strandline left by the last high tide will not only provide evidence of the creatures which live buried in the sand on the beach, but also those which live

offshore. A collection of colourful bivalve (two hinged) seashells might include long, thin razor shells, pink or orange tellins, a pelicans foot shell, variegated scallops and, if you are very lucky, a small European cowrie shell. The slipper



Pelicans foot shell

limpet is a common sight on strandlines in Southern parts of the country - there are so many to be found on some beaches, it is hard to believe that they are not native to this country at all. They are thought to have arrived from America with a shipment of oysters at the end of the last century and have since become a pest on oyster beds. They grow in chains or stacks, starting life as males, then changing into females!



European cowrie

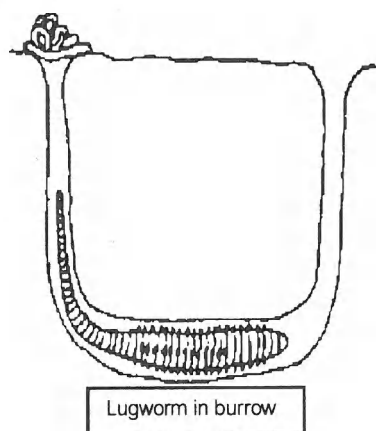
Other animals to look out for on the strandline are jelly-like sea-squirts and surprisingly large goose barnacles on drift wood. Mermaids purses, (skate or dogfish egg cases, right) often wash up, too.



## Life between the tides

When the tide is out, inhabitants of the sandy shore have to beat a hasty retreat and find shelter away from the sun, the wind (drying out is their biggest problem) and hungry predators. Because of this, most sandy shore creatures have wisely decided to live beneath the surface of the sand. However, even when the tide is out, a close look will provide signs of life.

One of the most common inhabitants, the lugworm, leaves a telltale sign in the form of the familiar worm

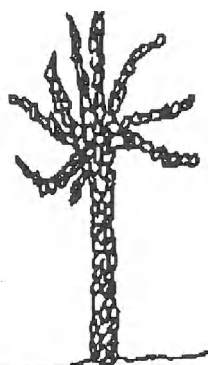


Lugworm in burrow

cast and a small depression just a few inches away. Living happily in a u-shaped burrow, the lugworm swallows sand which contains food in the form of organic particles. Once the worm has extracted the food, the excess sand is ejected at one end of the burrow as a cast. The depression nearby indicates the entrance to the burrow and the location of the head-end of the lugworm. Of course, these signs are also visible to birds that feed on the intertidal areas, so look out for wading birds probing the sand and pulling out long lugworms.

Using your detective skills,

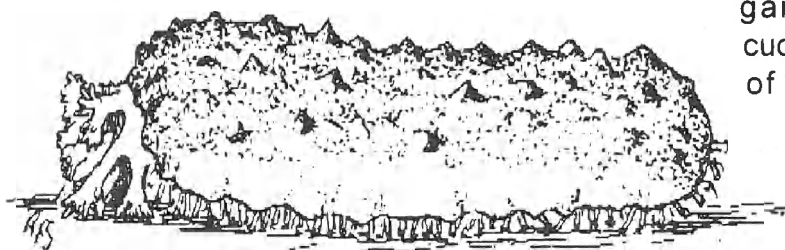
there are many other species to be found, if you know where to find them. You might come across a "forest" of tiny branching, sandy, tree like structures sticking up from the surface of the sand at low tide.



Sand mason tube

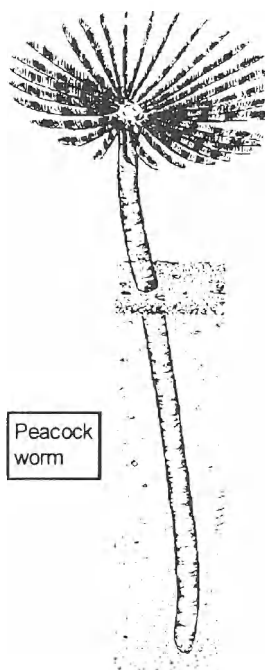
Sand masons build a burrow lined with mucus and sand grains; this combination makes the perfect tube which descends into the sand, but also extends just above the surface of the beach. When the tide is out the worm descends into its burrow - unfortunately many of the tops of the tubes are easily broken, but when the tide is in, the worm ascends, builds a new extension to the tube and a crown of tentacles emerges from the top to catch passing particles of food. The peacock

Sea cucumber



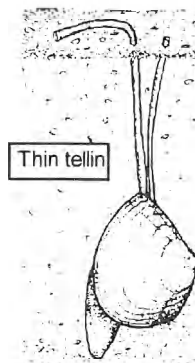
worm is similar to the sand mason, with tubes which protrude from the sand at low tide. When the tide returns, the worm appears to have "tentacles" in the shape of a peacock fan, but these are in fact gills used to extract oxygen from water, as well as to trap floating food particles.

For many animals, a soft body would be vulnerable without



Peacock worm

a hard outer casing. Bivalve molluscs, such as tellins, have hard shells to survive the period of exposure when the tide is out, and use a powerful muscular foot to pull themselves into the damp sand. Once beneath the surface the shells close tightly and the tellin is able to hide away waiting for the next tide (if the probing bill of an oystercatcher doesn't get hold of it first). When the tide comes in, the tellin extends its siphons into the water, taking in plankton rich water through one siphon and ejecting the waste through a second.

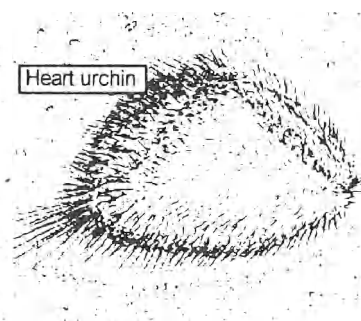


Thin tellin

In some areas, particularly the West of the UK, sea cucumbers play an important role in processing sand, in a similar role to earthworms in garden soil. The cucumber, a relative of starfish and urchins, consumes sand, digests food particles from it, and then ejects

the clean sand.

The heart urchin or sea potato also lies buried in sand. An echinoderm just like the starfish and sea cucumber, its tube feet pick up food particles, and small spines help dig the animal in.



Heart urchin

A strategy for staying hidden amongst the sand doesn't always guarantee an organism survival, because the sand also provides home to a number of active predators. Burrowing starfish are able to eat whole molluscs by using their arms and tube feet to prise the two shells apart. Then, the starfish will eject its own stomach out of its central mouth and over the soft mollusc, where digestive enzymes will act on the flesh and enable the starfish to consume its meal. Once finished, the starfish's stomach is taken back into its body through the mouth, and the empty shell is discarded.

Many birds, sometimes in very large numbers, also find a suitable meal on sandy shores. Oystercatchers in particular are good at finding cockles that are still agape or, if the bird has left it too late and the shells have closed, it uses its beak to smash its way in to extract the fleshy internal contents. Interestingly, oystercatchers which feed in this way develop blunt, stubby beaks compared with those which feed mainly on worms. The smaller sandpiper, another wader, is commonly spotted running up and down the water's edge, catching sandhoppers and other small crustaceans. Small crabs also hunt amongst the sand looking for a tasty morsel, however they in turn provide a meal for feeding gulls or raptors.

## Sand Dunes

Some sandy beaches are backed by areas of sand dune. Sand dunes are formed when large amounts of dry sand are blown inland across an open beach. An obstacle in the path of the sand, such as a clump of rotting seaweed or even the carcass of a dead rabbit, is enough to provide a barrier, and eventually a mound of sand will build up behind the obstacle. This process, which produces a fore-dune, can provide the birth of a complex dune system. Amongst the fore-dunes, just enough organic debris is available to provide the essential nutrients for plant growth and a few flowering plants will quickly take advantage of the situation. Sea-beet and sea-rocket have long, gripping root systems which can grow deep into the sand, providing a firm anchorage and finding moisture deep below the surface. Over time, more and more sand will build up and will eventually be colonized by marram grass, which tends to grow in tufts. These tufts trap sand efficiently, building up the dune system.

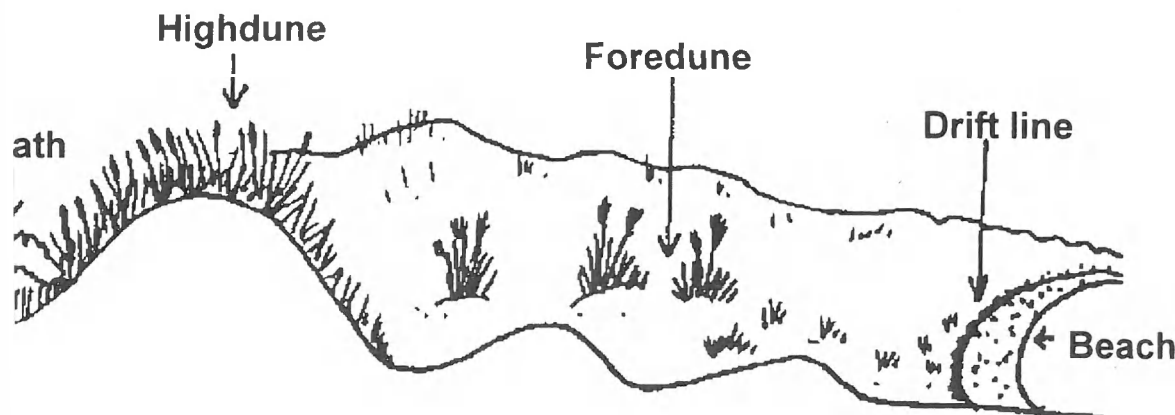
Dune plants have to be able to survive strong winds, desiccation, moving sand, lack of moisture and salt spray. The deep root systems are an important feature of dune plants. Sea holly has tough, glossy leaves to minimise water loss. Once the dunes have been colonized by plants, grazers, such as rabbits and deer are attracted to the area and in turn provide organic material in the form of droppings. At the furthest inland point of the dune system, marram grass is absent and a heath system tends to dominate.

Dune slacks are the hollows between the dunes. This is the

area where any moisture within the dune system tends to collect, sometimes in the form of small pools. A range of plants take advantage of the available moisture including perennial plants such as the sea bindweed. Some dune systems provide homes for a range of rare animals such as the natterjack toad, sand lizard and smooth snake.



Marram grass



Cross section through a dune system

# Threats to Sandy Shores

Pollution, recreation, sea defence works, and coastal development for industry and housing, are just a selection of the activities that are threatening sandy shore habitats.

Damage due to recreational activity such as horse riding, trampling and vehicular use is one of the major threats to sandy shores, and dune systems are particularly vulnerable. These activities tend to break up the vegetation that is holding the sediment together, leaving it open to wind erosion, which may eventually lead to widespread habitat loss.

In some dune areas, management schemes are being carried out - areas are fenced off to eliminate trampling and planting may be taking place.

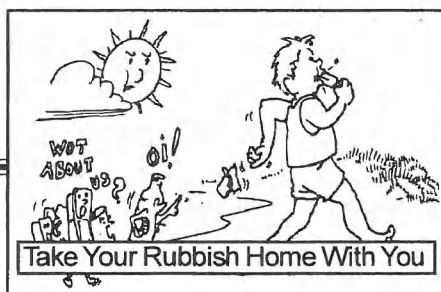
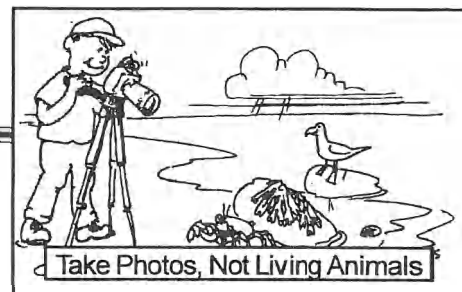
Water-based recreational activities such as wind surfing and jet-skiing can have an impact on the communities that live in sandy shallows, especially when access to the water is concentrated in certain areas. Jet-skis and outboard motors can literally 'mow' eel grass beds.

Loss of sediment supply due to direct removal of sediment or indirectly, as a result of sea defence works elsewhere along the coast, is also a major threat to soft coastlines because the impact may only be seen in the long term.

Litter left by visitors and washed up on the beach from the sea is also a big problem along many of our beaches, causing unnecessary harm to wildlife and resulting in large clean-up bills.

## WHAT YOU CAN DO TO HELP

◆ Follow the **Seashore Code** :-



- ◆ Take part in MCS's annual **Beachwatch** clean-up and **Adopt-a-Beach** campaign to clean up our beaches and seas
- ◆ Join the Marine Conservation Society today and support our campaigns to protect the marine environment for wildlife and future generations.

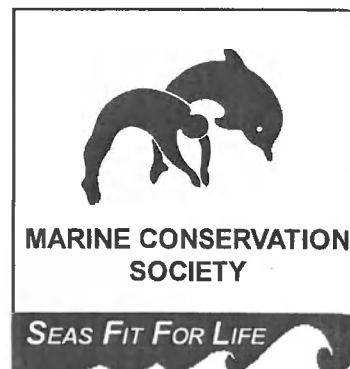
For further information, send a stamped, addressed envelope to:

## The Marine Conservation Society

9 Gloucester Road Ross-on-Wye Herefordshire HR9 5BU

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# KELP FORESTS

RJH01/00

FOR MOST OF US, BRITAIN'S UNDERWATER FORESTS ARE HIDDEN FROM VIEW - ONLY AT VERY LOW SPRING TIDES CAN YOU CATCH A RARE GLIMPSE INTO THESE RICH AND FASCINATING HABITATS. LIKE RAINFORESTS AND MATURE WOODLANDS ON LAND, THEY PROVIDE FOOD AND SHELTER FOR THEIR INHABITANTS. PEOPLE REALISE THAT HABITATS ON LAND ARE UNDER THREAT FROM POLLUTION, DEVELOPMENT AND OVER-EXPLOITATION, BUT WHAT ABOUT KELP FORESTS?



Reg Charity No 1004005

## What is "kelp"?

Kelp is a general term used to describe large brown seaweeds, usually the "Laminariales". These may reach several metres in length and are given common names such as sea belt or sugar kelp, and oarweed or tangle weed. Sugar kelp *Laminaria saccharina*, furbellows *Saccorhiza polyschides*, tangle or oarweed *Laminaria digitata* and, particularly, rough kelp or cuvie *Laminaria hyperborea* are the most common UK and North Atlantic species. They are all frequently exposed at very low spring tides when the large fronds can be seen just above the water's surface. Dabberlocks *Alaria esculenta* is also common, though usually found in less dense populations.

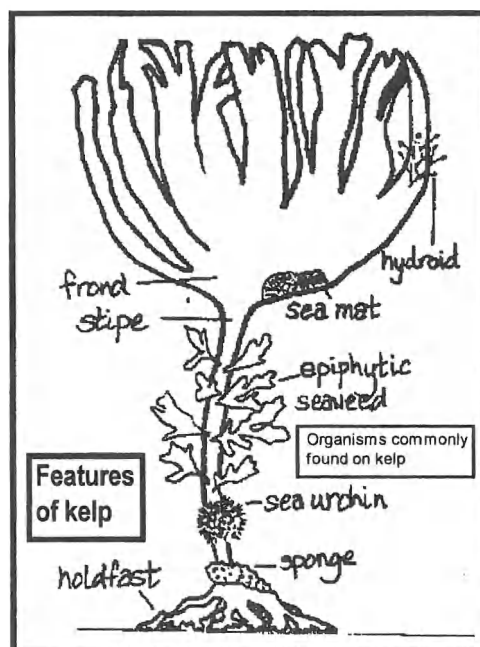
Kelps are found all around the coast of Britain, where ever there is a suitable rocky surface for attachment. These often form very extensive "forests" which provide shelter and food for a rich variety of marine wildlife.

Rough kelp is the most familiar species, particularly to divers who may find it difficult to navigate through their thick forests. After storms, beach goers will find huge mounds of kelp mixed with other weeds washed up onto sheltered shores, providing feast and shelter for invertebrates and birds - kelp is almost as important when dying as when alive!

## Features of kelp

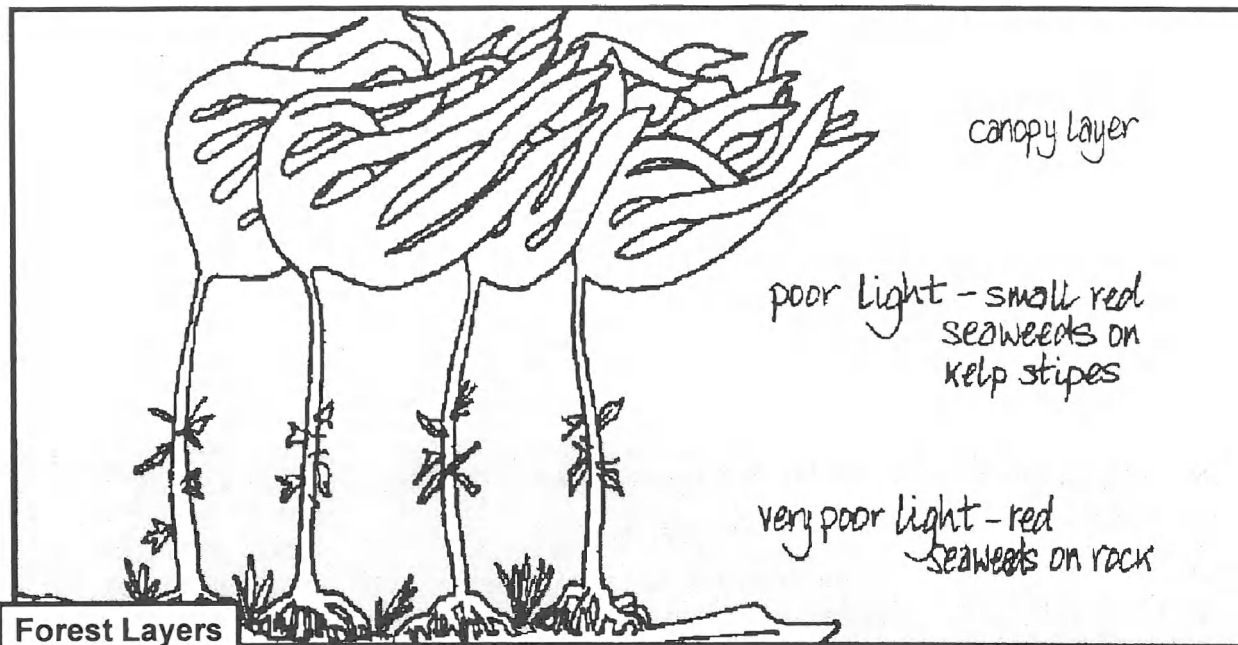
Rather than a trunk, kelps have a strong but flexible **stipe**. They do not need to be rigid because the water column gives support, and flexibility allows each kelp plant to move with waves and currents without breaking. Kelps have large fronds which are effectively the equivalent to branches and leaves on a tree. These provide the **canopy** layer of the kelp forest, just like the top of tall tropical hardwood trees.

Not much grows on the fronds because they have a slippery surface, due to a mucus layer which is periodically sloughed off - the perfect antifouling technique! This slippery surface also helps prevent the fronds from being ripped apart in storms.



Most kelp plants require a stable and solid surface to grow on, although sugar kelp actually prefers to be attached to more mobile pebbles and boulders. Kelp plants attach to surfaces by a **holdfast** - roots are not needed to soak up water and nutrients from soil because kelps are able to absorb all they need from the surrounding water. Like plants on land, kelps and other seaweeds rely on photosynthesis for energy production. The amount of light in the sea varies enormously from place to place, and also decreases rapidly with depth. The availability of light determines the extent of the kelp forests and the depths to which they are found.

Other environmental conditions also influence the size and distribution of kelp, particularly wave action. The largest forests are found where wave action is only moderate. In higher energy areas, plants are often torn from the substrate. Sometimes, the force of water movement on the large plants causes the attached rock to be torn away with the holdfast! The buoyant kelp will carry the rock away, eventually to be washed up on the shore where the kelp will rot away and leave the rock as an addition to the beach sediment budget. Some scientists maintain that this is an important process, particularly along the South UK coast, as a major contributor to coastal erosion and accretion.



Like a rainforest, several layers can be easily recognised in a kelp forest. Many other organisms attach themselves to the stable kelps, and space is in such demand that many organisms may grow on top of one another.

The rock to which kelp attaches will have many encrustations of seaweeds, seamats, tube worms and barnacles. The holdfast and lower stipe, where light levels are quite poor, may have red seaweeds attached, and hydroids, bryozoa, sea anemones and blue rayed limpets may be found.

### Forest Life

Sponges and sea squirts grow all over the red seaweeds and kelp holdfasts. 389 plant and animal species have been recorded in 72 individual holdfast habitats! The complex and intricate maze in the holdfast provides an ideal nursery ground for many creatures because of the food and shelter it affords.

The stipe and blades of all kelps are often encrusted with colonies of bryozoa ("moss animals", or "sea mats"). The mat consists of delicate compartments, each housing a minute individual animal. The colony develops through asexual "budding", but each colony contains both males and females. A fertilised egg becomes a free swimming larva, which swims and feeds before attaching itself to another kelp plant, and turning into a "zoid".

Some animals climb the plant in search of food, grazing on encrusting mats and seaweeds, or even eating the kelp. Occasionally, the evidence of grazing can be seen where scar tissue forms on the fronds.

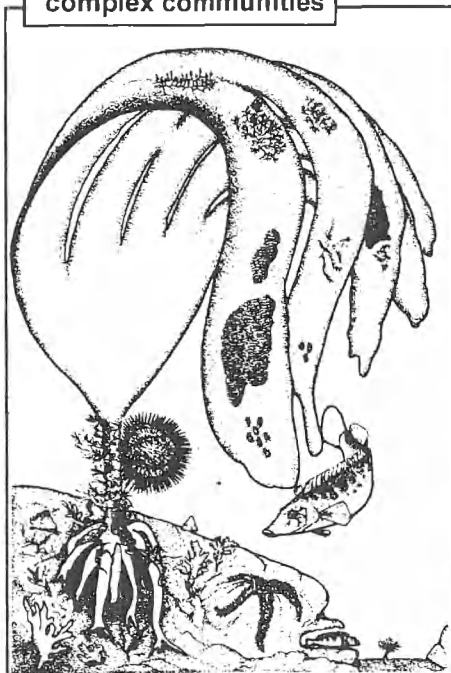
Common sea urchins are such climbers, with a voracious appetite. They graze on both the kelp and its seaweed and sea mat attachments, and may also graze the rocky substrate clear of kelp sporelings.

Sometimes armies of urchins invade and destroy whole kelp forests, when the urchin population itself will crash due to the resulting lack of food. But urchins do play an important role in maintaining a mosaic of seaweed and encrusting animal communities when present in moderate numbers.

Blue rayed limpets are also common inhabitants of the kelp forest. These beautiful little molluscs with bright blue-striped shells have the ability to graze on the fronds when young, but as they grow larger they migrate down the kelp. Rather like a beaver eating away at the base of a tree trunk, the limpets may eat until the plant attachment is weakened and the whole arrangement is swept away.

Small fish, crabs and lobsters lurk amongst the holdfasts and amongst the boulders on the sea bed. Tiny porcelain crabs have a flattened body for moving easily amongst the weeds. Young fish such as herring and mackerel can also be seen swimming amongst the canopy, like flocks of birds would in a forest. It has been estimated that 90,000 juvenile fish may hide in one acre of some kelp forests, and it is likely that kelp forests play an important role in maintaining commercial fish stocks.

### Kelp forests support complex communities



## Seasons of change

Like deciduous trees, which shed their leaves annually, kelps are perennial and shed their fronds each year. However, unlike in terrestrial forests, this actually occurs in most volume during spring rather than Autumn. A new frond starts to grow beneath the old one during winter, reaching full size by spring. The old frond is then shed, and this is the reason why large amounts of seaweed are washed up on the shores during spring and early summer (sometimes called "Maycast"). This can cause problems on popular bathing beaches, because many people think that rotting seaweed is both slightly and unhygienic, and should be removed. Some beaches are mechanically cleaned daily to comprehensively remove it. However, the breakdown of seaweed adds a number of nutrients to the inshore ecosystem, and also provides shelter for many vertebrates - sandhoppers, flies and others breed in the summer months, making full use of their free accommodation and food supplies.

Dangerous bi-products are produced in the breakdown of the kelp, just rich organic matter. This **articulate Organic Matter** provided by kelp is a hugely important source of carbon and energy for large marine and coastal systems, so MCS maintains that seaweeds should not be removed on the beach.

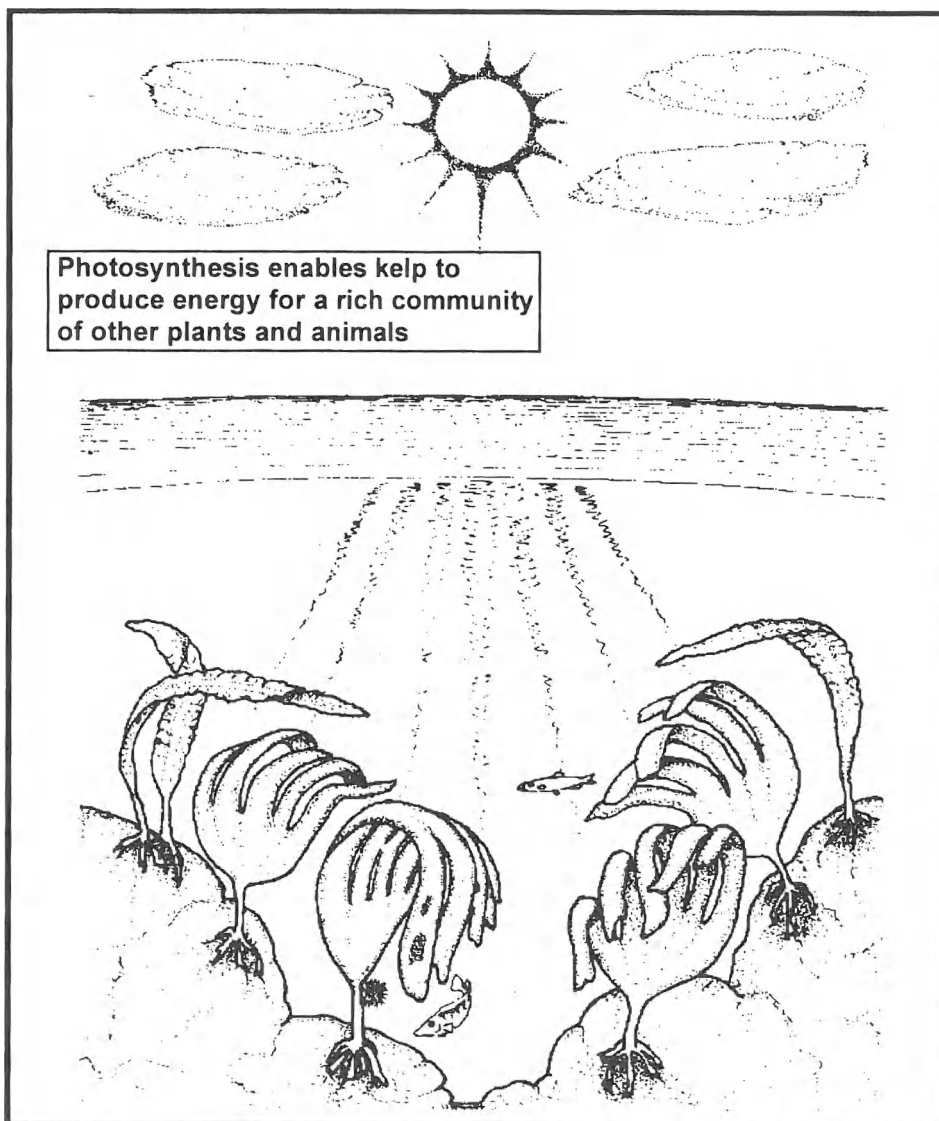
Many of the seaweeds, sea mats and hydroids that colonise the kelp die back during the winter, but rapidly re-colonise during the summer months. Competition will lead to an altering community structure throughout the season, which is replayed each year. Some kelps are very long lived - the rough can live for up to 12 years. You can get a good estimate of the age of a kelp plant by counting the annual growth rings that form in the trunk, just as with the trunk of a tree. Each year, too, the kelp also adds another ring of "roots" to the holdfast.

## The Kelp Life Cycle

The large brown plant that is usually thought of as kelp is actually just one stage in a life-cycle. At this stage it is termed the **sporophyte**, which is the longest lived phase. It is able to release spores, when mature, from **sporangia** in the frond. The spores then settle elsewhere, having been spread widely by current and tide, but they are not immediately able to grow as kelp - they sit as stunted male or female **gametophytes** which produce either one egg or one sperm. Only if an egg becomes fertilised by a liberated sperm will it grow, using sunlight to produce energy through photosynthesis, into the familiar large plant. It is then able to reproduce within about two growing seasons. While many gametophytes will never become mature sporophytes, enough do survive to produce the thick forests around our shores.

## Giant Kelp

Kelps are distributed in temperate seas around the world. Extensive beds grow around China, Japan and Korea. The Western sea boards of North & South America are colonised by the enormous giant kelps *Macrocystis* species - much bigger plants which grow in relatively deep water. Giant kelps also play a major role in absorbing the energy from storm waves, and in the processes of coastal erosion and accretion. Because of their scale, colonising depths to as much as 20 metres or more, giant kelps are hosts to a large number of seaweeds and animals, including hermit crabs, the bright señorita, bronze perch, Garibaldi fishes, the sea otter, and even grey whales who sometimes pass through. The ecological importance of the forests has long been recognised in the US, and some areas of forest are protected by law.



## Uses of kelp & seaweeds

Seaweed, and particularly kelp, has been collected for centuries to cure various ailments. The ancient Chinese and Greeks used kelp for its iodine, to treat goitre, and kelps are still harvested for iodine extraction in some areas.

Seaweed collecting in general is an important commercial activity around the world, because seaweeds contain jellylike or glue-like substances called **colloids**. The main examples of these are algin, agar and caragheen. Alginates are used in the making of ice cream, custard powder, salad dressings, and pickles. As food, the value of seaweed lies in their high mineral and vitamin content. Plant feeds such as *Baby Bio* are based on nutrients obtained from kelps and other weeds.

### Uses of Kelp in manufacturing

Alginates are used in:

*Pharmaceutical*

Anti-acid tablets

Aspirin tablets

Calamine lotion

Toothpaste

Surgical jellies

*Food*

Cake icings

Salad dressings and creams

Ice cream

Chocolate drinks

Sterilised cream

Cheese

Beer

*Rubber*

Latex creaming & thickening

Foam rubber for cushions etc.

Rubber coatings

Tyres

Electrical insulation

*Textiles*

Textile print paints

Laundry starch

*Paper*

Milk containers

Insulation board

Food wrappers

Greaseproof paper

*Miscellaneous*

Paints

Polishes

Waxes

Ceramic glazes

In Norway, inshore fishermen crop kelp using dredges with cutting edges dragged behind a boat. Commercial seaweed harvesting in the UK occurs principally in Scotland. Stranded seaweed has been collected for many centuries by crofters, who used it to fertilise the sandy strip of land adjacent to the beach. Processed for consumption or manufacturing, kelp may be worth £5,000 per tonne, but prices for raw materials are low and variable due to world competition.

## Threats to kelp forests

**Seaweed harvesting** may have significant ecological effects. Cutting and removal of large quantities upsets the balance of resident communities. Harvesting may affect several kinds of bird. The black guillemot, for example, feeds extensively on butterfish and gobies which favour kelp dominated shores. Sea otters may also be disturbed by the removal of kelp beds which provide rich feeding and resting grounds. Giant kelp is harvested for use as soil conditioner and fertilizer - it was hand-picked from beaches, but the industry is now highly mechanised using grabs and pumps that are not species selective.

Removing seaweed can also increase erosion along the shore. Kelp acts as a natural sea defence, absorbing and dissipating wave energy so effectively that trials have been carried out with artificial seaweed anchored close inshore to minimise erosive power of incoming waves. If kelp is removed the shore becomes more exposed and bedrock, boulders and shingle may be displaced. The Coast Protection Act (1949) prevents the removal of seaweed if it is protecting the beach.

**The removal of predators** such as sea otters in North America earlier this century, along with over fishing of lobsters, could well have caused an increase in grazing sea-urchin populations, which led to diminishing giant kelp forests.

**Coastal development** may cause an increase in the amount of run of fine silts and muds. This will increase the turbidity of the water thereby affecting the amount of light entering the water and restricting the growth of kelp or having a direct smothering effect on the kelp. Dredging activities offshore may have the same effect.

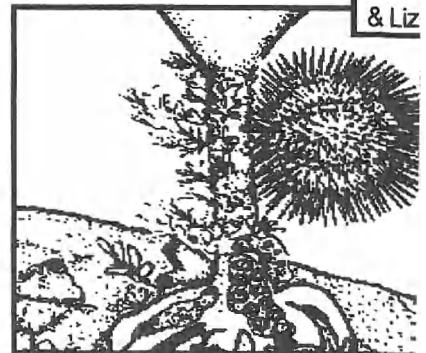
**Bioaccumulation of radio-nuclides and heavy metals** in kelp is of particular concern near nuclear power installations. Kelp is a primary producer, which means that it is an important food source for grazing animals, which are later consumed by other animals. Metals may build up in tissues, seriously affecting the health of larger mammals, including humans.

## What can you do to help?

- Do not collect live specimens
- Washed up kelp and other seaweeds should be left on the strandline
- Follow the Marine Conservation Society Seashore Code (obtained from the address below)
- Join the Marine Conservation Society and support our work to promote sustainable marine resource management.

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Illustra  
Dr. Liz  
& Liz



# DEEP OCEAN

PARTS OF THE EARTH'S OCEANS ARE EXTREMELY DEEP. UNTIL RECENTLY, THESE AREAS WERE CONSIDERED TO BE ALMOST DEVOID OF LIFE, BUT NEW OCEAN TECHNOLOGY, SUCH AS REMOTELY OPERATED SUBMERSIBLES, HAS PROVED THAT THIS SEEMINGLY HOSTILE ENVIRONMENT IS FULL OF LIFE AND MANY SURPRISING NEW DISCOVERIES.



Kraken, giant squid, mermaids and other non-terrestrial life forms - there are myths and legends from the ocean abyss. What exactly is found at the bottom of our very deep blue seas?

## What is the Deep Ocean?

The oceans cover 75% of the world's surface and contain 97% of its water; 90% of the seas lie beyond the shallow continental margins, and most are deeper than 1 km. It could be argued that the deep sea environment is typical of the planet and yet it is an area about which we know very little and is the subject of much controversy. With the advent of modern science we have been able to discover what some of the deep ocean is like but there is still a vast area that remains unexplored. One thing we do know is that life at these depths is dominated by animals, not plants, since light cannot reach these depths.

### The physical environment:

The shape of the seafloor is shown in the diagram below; the deep ocean is an area of both sea floor spreading and sedimentation. The

deep sea begins where the continental shelf breaks into the continental slope. The slope marks the boundary between the oceanic and continental crust; these areas of crust are in fact a very dynamic system of plates; where two plates are pulling apart from each other, material from deep within the earth rises up to fill the space, thus producing new seafloor in the form of an **ocean ridge**. This process is known as **sea floor spreading** and occurs on a **constructive margin**. Where two plates collide, one goes beneath the other (a process termed **subduction**) and a trench is formed. Such margins are called **destructive margins**. Between the ridges and the trenches lie the **abyssal plains** which are vast (hundreds of thousands of sq.kms) areas of sediment. Near to land masses the sediment piles up to form **continental shelves**.

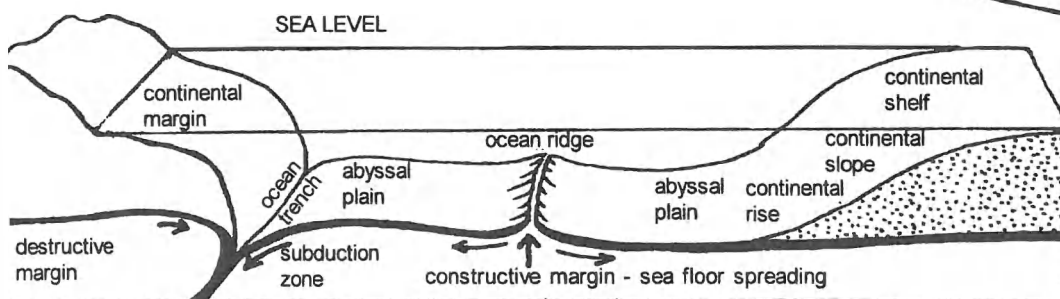
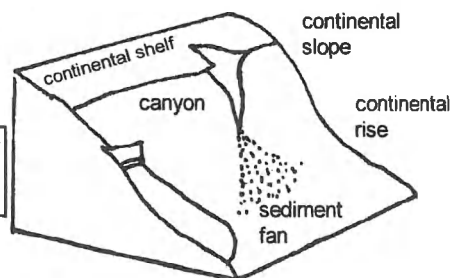
## Features of the deep ocean:

### 1 Continental margins

There are two types of continental margin:

**Atlantic** - constructive margins are characterised by little earthquake activity. Generally there is a wide continental shelf, sometimes dissected by submarine canyons and turbidity currents. **Turbidity currents** are submarine avalanches and occur when large amounts of sediment accumulate on the continental slope (from large river systems on land). Failure, due to mass gravity, sends the sediment flowing down the slope, sometimes reaching 100km per hour until it comes to rest, often hundreds of miles out onto the abyssal plains.

Features of the Continental Margin >



Deep Ocean Processes <

**Pacific** - characterised by a lot of earthquake activity because they have destructive margins with a subduction zone. Any sediment washed from the adjacent land becomes trapped in the trench which may be as deep as 11km.

## 2 Ocean ridges

These are formed from new material which forces its way to the surface of the seabed where two plates are moving apart. Because this new material has come from deep within the earth, it is still molten when it reaches the surface and spreads away from the centre, cooling in the cold sea water. The rate of material added to each side of the ridge varies; the **Mid-Atlantic Ridge** is a slow spreading ridge with an average of 1cm a year being added to either side, whilst the **East Pacific Rise** is fast spreading with approximately 6cms added per year. The UK has led research into Mid-Atlantic ridges, with the "BRIDGE" programme completed in 1999.

## 3 The abyssal plain

The deep ocean floor between the continental margins and the ocean ridges is termed the abyssal plain. These are huge flat plains which are at, or deeper than 4,000 metres below sea level and continue for kilometre after kilometre. Much of the abyssal plain is covered by a thick layer of **ooze** made up of the remains of minute animals and plants. In the very deepest parts of the ocean the sediment is an extremely fine, inert, red clay; at depths of 6,000m, the pressure is great and the sediments are not so obviously biological in origin. Below 5,000 metres, the pressure of the water causes the calcium carbonate

to go into solution (the **calcite compensation depth - CCD**) which influences the distribution of sediments. The CCD is the depth where the supply of calcium carbonate to the sea floor is balanced by the rate at which it dissolves.

There are several different types of ooze:

**Calcareous oozes** are made up of **foraminifera** which are comparable in size to phytoplankton and have calcareous skeletons. These skeletons form important deep sea oozes beneath the depth where calcareous remains disappear into solution, i.e. above the CCD.

**Globogerina ooze** is the most widespread of the deposits over the greater part of the depths of the Atlantic and much of the Indian and Pacific Oceans. It covers up to 50% of the deep ocean floor and extends to a depth of 6,000m and is 95% calcium carbonate.

**Pteropod ooze** is made up of the shells of pteropods and occurs in subtropical parts of the Atlantic down to 3,500m.

Siliceous and diatom oozes form below the depth of the CCD and are made up of siliceous material from tiny plant plankton known as **diatoms**. These sediments occur in an almost continuous belt around Antarctica, beneath the Southern Ocean.

**Radiolarian oozes** are found at depths of between 4,000m and

8,000m beneath the tropical parts of the Pacific and Indian Oceans. They are made up of the skeletons of **radiolarians** - tiny animals with radiating spines that live in the plankton.

## 4 Deep ocean trenches

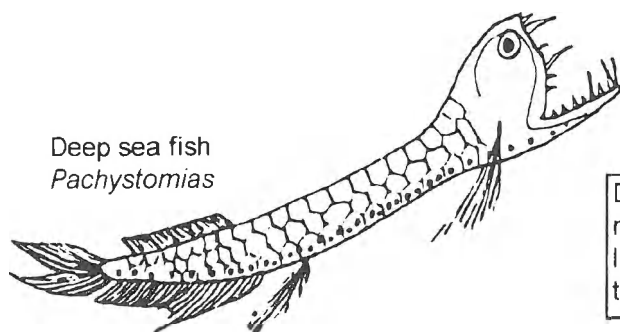
The deep ocean trenches are sometimes also known as the "**hadal regions**". These are the deepest parts of the ocean and are really chasms in the abyssal plains, descending from 6,000 metres in depth to, in some cases, 10,000 metres. The deepest ocean trench is the **Marianas Trench** in the Pacific Ocean, it is 11,034 metres deep (deeper than Mount Everest is high).

## 5 Seamounts

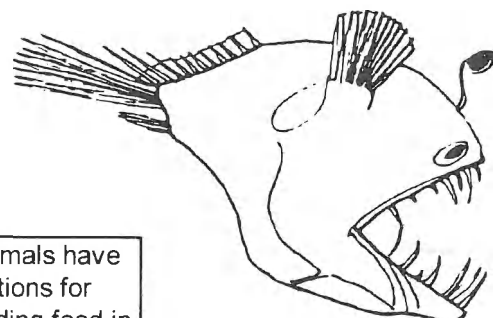
These are peaks (usually volcanoes) rising up from the ocean floor towards the surface. Some actually break the surface of the sea to create islands, but where they do not break the surface they are termed seamounts. Some seamounts support very little life, but others support rich ecosystems. They are a favourite spot for commercial fishermen because large stocks of fish tend to congregate around the mounts, which provide food and shelter. Where the water is clear and rich in nutrients, communities of plants and animals flourish, there being intense competition for space amongst attached organisms.

6

Gulper eel



Deep sea fish  
*Pachystomias*



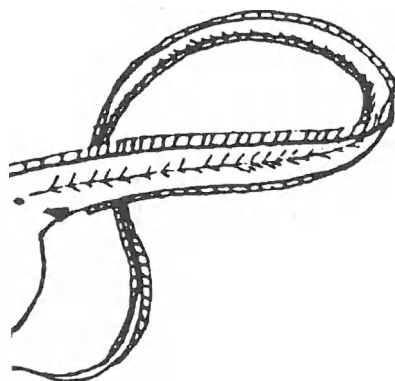
Deep  
angl

Deep sea animals have many adaptations for living and finding food in the dark abyssal depths

## Life in the deeps

In general it is believed that the deep oceans are sparsely populated because of the difficult conditions and the harsh environment. However, the forces of evolution have ensured that life has reached even the deepest parts of the ocean. Unusual, and to our eyes, ugly and bizarre animals have developed. Fish, echinoderms, crustaceans and molluscs are presented in the depths and since no light penetrates this far, many animals have forsaken eyes and have developed long feelers instead. Some have even developed systems for producing their own light - a process termed **bioluminescence**. This light is used as a lure to attract food; the deep sea angler fish is a good example with its glowing lures hanging down over its mouth to entice other fish to come its meal.

Since food is scarce to come by in the depths, some fish have developed stomachs with a huge capacity and can eat prey that are larger than themselves, these fish are aptly named the "gulpers".



### Hydrothermal vents - hot springs in sea

Though, in general, life in the deep ocean can be described as sparse, there are areas where there is an exception to this rule. Hydrothermal vents (also known as **black smokers**) occur where the earth's crust is thin and new sea floor is being formed. They have only recently been discovered. Along these spreading seas, mini volcanoes appear on the sea bed which belch out sulphur through chimneys up to 30m high into the surrounding ocean. They also cause a local increase in temperature by spewing out very hot water;

temperatures of 350 degrees Celsius have been recorded from some of the sulphur chimneys.

Hydrothermal vents are effectively self-contained ecosystems. The areas around these vents are rich with life, particularly **sulphur reducing bacteria** and dense populations of animals, because the food supply is so concentrated. Many animals are very strange and completely new to science; some of the most spectacular are the giant red **Pogonophoran tube worms**, which can grow up to 2 metres long and live in white tubes. These worms do not have any mouth parts or digestive organs. They survive in the deep ocean because they can absorb nutrients from the surrounding water directly through their skin. Some vent animals live in a symbiotic relationship with bacteria; the bacteria use the sulphides as food and in return they supply food to the host animal. Other gigantic forms of life include clams, which grow up to 30cms in length. The bacteria are effectively the primary producers of the vent food web and support a variety of other animals.

### Exploring the deep ocean

Although research ships have been used for deep sea studies for many years, it is only within the last three decades that enormous advances have been made. Exciting discoveries of the deep have been made possible by the development of deep submergence vehicles. Some are manned, others unmanned - both are able to carry out *in situ* studies.

**Manned submersibles** such as ALVIN were built to withstand the tremendous pressures of the deep ocean. Small and manoeuvrable, ALVIN is capable of exploring depths to 400m. ALVIN was used to explore the wreck of the SS Titanic in 1986.

**Unmanned submersibles** are also known as **remote operated vehicles (ROVs)** and include a range of towed and free-moving vehicles. Although ARGO does not have its own

propulsion it is capable of reaching depths of 6,000m, being towed on a cable which supplies all the power to the vehicle.

TOBI and GLORIA are deep-towed systems for making high resolution maps of the sea bed and SeaSoar is an undulating vehicle for continuously measuring ocean properties to depths of 500m.

To understand better how the world's oceans 'work', it is necessary to increase the range and rate at which data is collected. New, exciting technology is being developed all the time. It would be too costly to collect all this new data from the research ships such as RRS Discovery. As a result, **Autonomous Underwater Vehicles (AUVs)** are being developed to help collect data, allowing the research ships to be used in their primary role as floating laboratories. One of these vehicles is **DOLPHIN (Deep Ocean Long Path Hydrographic Instrument)**. It will make a sequence of full-depth profiles of ocean properties by undulating between the surface and the seabed. Sophisticated underwater cameras, nutrient sensors and sonar techniques are being developed for studying ocean biology and chemistry.

Studying the deep ocean needs sophisticated equipment and support from large ocean-going research vessels. Losses of equipment are common place, and this, combined with the expense of working at sea, leads to extremely high costs for studying the abyssal depths.



*Pogonophoran tube worms live in white tubes and can grow up to 2 metres long.*

## Oceanographic Research

Most oceanographic research carried out by UK scientists is based at the Southampton Oceanography Centre. The Centre is a joint venture between the University of Southampton and the Natural Environment Research Council (NERC). The research ships *Discovery*, *Charles Darwin* and *Challenger Discovery* can be seen moored up alongside the Centre when they are not at work on the world's oceans.

For further information:  
Southampton Oceanography Centre,  
Empress Dock  
Southampton SO14 3ZH  
Tel: 01703 596666

## Man's impact on the deep sea

Most human exploitation of the seas has been confined to a relatively narrow strip around the coast, or on the continental shelf. Much of the deep sea floor remains unexploited and there is still much research being carried out to find out exactly what does exist on the deep ocean floor. There is a growing interest in the bacteria found along hydrothermal vents and the mining of **manganese nodules** and other deep seabed minerals. As with research, any exploitation of the deep ocean is going to be expensive.

## Living Resources

Deep sea resources have only been exploited to a limited extent because relatively little is known about the living resources and the costs of recovery involved are prohibitively high. However, some deep sea species are harvested; the **roundnose** and **roughhead grenadier** are fished by fleets in the Arctic and NW Atlantic, but catches are already declining, possibly due to overfishing. Fish are also caught on a commercial scale around seamounts, particularly around Australia and New Zealand. Little scientific investigation has been carried out on deep sea fish stocks, and if man is contemplating expansion of commercial fisheries into the deep sea, a lot more biological research is required to ensure that any exploitation is only carried out on a sustainable level.

## Non-living Resources

The deep ocean contains extensive deposits of minerals. The most well known are the manganese nodules found on the abyssal plains of all oceans. The environmental impact of mining is of great significance; any mining carried out will be on a large scale to make it commercially viable and extensive areas of the sea bed will be affected. All the proposed systems for mining these deep sea minerals involve scooping up large amounts of sediment to extract the mineral resources.

Disturbance through collection will damage biota and change the ecology of the area; any attached organisms will be destroyed and the discharge of waste sediments not required (as a plume of suspended sediment) will also affect the ecology through smothering, and the process may also release toxic trace elements.

## Waste Disposal

Man continues to produce waste that is highly dangerous and is constantly seeking new areas to dispose of it. Land waste disposal sites are limited and man already uses near shore waters as a convenient dumping ground for large amounts of waste of varying toxicity.

As the amount of waste produced by humans increases, we will look more and more towards the deep sea as a convenient repository, particularly for very dangerous waste that cannot be dumped into shallower waters over the continental shelf. Indeed, the deep ocean is already being used to dispose of dredge spoil, pharmaceutical, industrial and radioactive waste.

It is clear that Man will attempt to fully exploit the resources of the deep sea in the future, but we must ensure that it is not carried out until we fully understand this complex and vulnerable ecosystem.

## WHAT CAN YOU DO TO HELP?

- ◆ Find out more about the deep sea environment. You will be amazed at the life forms that have been found - and what of those yet to be discovered?
- ◆ Join the Marine Conservation Society today and support our campaigns to protect the marine environment for wildlife and future generations.

For further information contact:

### Marine Conservation Society

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MARINE CONSERVATION  
SOCIETY

SEAS FIT FOR LIFE



THE MARINE CONSERVATION SOCIETY (MCS) IS THE NATIONAL UK CHARITY  
DEDICATED TO PROTECTING THE MARINE ENVIRONMENT & ITS WILDLIFE

# SHALLOW SEAS

FROM THE SURFACE, THE WATERS AROUND THE BRITISH ISLES SEEM COLD AND GREY, AND MAY APPEAR LIFELESS. NOTHING COULD BE FURTHER FROM THE TRUTH, HOWEVER - OUR SHALLOW SEAS ARE AS COLOURFUL AND FULL OF LIFE AS THOSE FOUND ANYWHERE IN THE WORLD'S OCEANS.



Reg Charity No 1004005

as a series of islands, sits on continental shelf that extends far into the Atlantic Ocean, so is fringed by shallow seas:

**North Sea** is very shallow over the area with an average depth of 100m. Both ends of the North Sea are open to oceanic influences; from the west via the English Channel and from the north by the Atlantic ocean. The seabed sediments include sands, shales and muds.

**English Channel** stretches from the Straits of Dover to a line joining the Scilly Islands and Ushant. Its western boundary adjoins the Celtic Sea's northern boundary. Gravel forms a large area in the mid channel, with mud near to the shores of France and England.

**Celtic Sea** lies to the south west of the British Isles, from the Bristol Channel inland SW Wales out to 200m depth. The Bristol Channel is an extension of the Celtic Sea into the English estuary. Sea floor sediments here are varied and include sand, gravel and shales and clays.

**Irish Sea** is semi-landlocked between Britain and Ireland. The seabed is composed of gravel, sands and muds, strongly influenced by the tidal regime. There are extensive areas of fine silts and shales and muds.

## Environmental factors affecting the ecology of shallow seas.

### Temperature:

The geographical position of the British Isles means that it is influenced by a number of temperature provinces, which influence where species live. The warmer waters of the North Atlantic drift (an offshoot of the Gulf Stream which originates in the western Atlantic ocean) influence the western shores whilst the southern coast of Britain is also periodically influenced by warmer waters from the Mediterranean. Northern shores are influenced by both the North Atlantic Drift and cold Arctic currents. Temperature variations occur seasonally and with depth.

### Bedrock:

**Bathymetry** (seabed topography) and **seabed sediments** are an important feature because they determine the nature of bottom dwelling (**benthic**) ecosystems. If the water were drained from the seas surrounding the British Isles, we would see a diversity of surface features. As on land, the underlying geology influences the features of the seabed along with the amount of sediment available for transport. Rocks are affected by tidal currents and wave

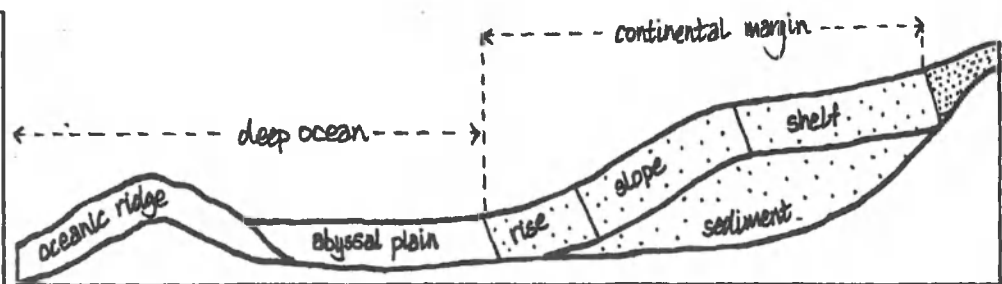
patterns, producing a range of features. Soft, easily eroded rock tends to produce a flat seabed, and the availability of vast amounts of sediment and strong tidal currents produce features such as sand waves which constantly change. Layered strata consisting of alternate soft and hard rocks erode to give interesting cliffs, caves and ledges.

### Water movement:

Waves and tidal currents influence the distribution of marine organisms. Plankton in the pelagic zone is moved around by currents - because the juvenile stages of many marine organisms start life in the plankton, their distribution ultimately affects the distribution of species on the sea bed. The tidal regime has a profound effect on the ecology of the coastal environments - the Bristol Channel experiences the second highest tidal range in the world (12m, compared to 15m in the Bay of Fundy), whereas the south coast experiences a range of about 2m. Such water movements have an important influence on the benthos, affecting sediment movement, turbidity and the deposition of sediment. Tidal races and overfalls occur at certain localities; where flow is restricted between narrow gaps or between islands, tidal streams, sometimes approaching as much as 7 knots, will be found.

The ocean floor can be divided into two distinct regions, the continental margin and the deep ocean.

The continental margin is made up of the continental shelf (a shallow platform adjacent to land masses), slope and rise.



In **sheltered** areas, organisms are not bombarded by waves, currents and swirling sediments, but mixing is also reduced, affecting the supply of nutrients and dissolved gases. Constant deposition of sediment may smother bottom dwelling organisms, but **detritus feeders** such as worms and snails thrive. In **exposed** localities, mixing and renewal of organic materials means that **suspension feeders** such as bivalve molluscs, sponges, and anemones compete with each other for living space. However, turbidity is also greater than in sheltered areas, which affects the level of light available for photosynthesis. In strong currents organisms may be damaged and exposed to great physical stress.

**Light:** An important factor in determining the species distribution because it dictates primary production and algae growth which forms the basis of oceanic food webs. In well lit areas, an algal-dominated community develops (referred to as the infralittoral zone). As depth increases, the level of light decreases and animals predominate (the circalittoral zone). Herbivores and grazers can be found in the infralittoral, along with more mobile animals seeking shelter and food. Kelp forests provide a suitable habitat for a diverse range of flora and fauna.

**Salinity:** Salt concentration is most variable in estuaries where there is a constant input of freshwater. This input will change over the tidal cycle and with weather. In general, a drop in salinity leads to a reduction in the range of species.

## All at Sea

Because we don't often see the abundance of tiny plankton suspended in the water column, we tend to forget that photosynthesis provided the basis of oceanic food webs. Being dependent on sunlight, primary productivity (growth of phyto-plankton) is restricted to the near surface layers. To flourish, plankton require warmth and a constant supply of fresh nutrients. In shallow seas, which are no deeper than 200m, nutrients are easily brought back to the surface by currents and the stirring effect of storms, so there is generally high productivity in coastal regions compared to the open ocean. Plankton is made up of plants and animals that have limited propulsion, so are at the mercy of the waves and currents. Zooplankton are the animal plankton, and such is the variety that this includes tiny worms to jellyfish which may grow to be over a metre across with long trailing tentacles. Zooplankton feed on the plant

cells and in turn form the diet of a whole host of marine organisms. In the relatively shallow and well lit seas of Britain, conditions are perfect for phytoplankton growth, particularly during the Spring and Autumn. Events known as blooms result from a good circulation of nutrients coupled with bright sunlight. In the Spring, the blooms signify the availability of food on which small copepods and other zooplankton graze. These multiply quickly, and reduce the levels of phytoplankton considerably. In Autumn, nutrients circulated by increased water movements allow phytoplankton to flourish again while waters are warm.

Copepods are the most abundant forms of zooplankton, which permanently live in suspension, and form the basic diet of many other organisms in the sea. Mackerel, herring and other juvenile fish consume them in great quantities.

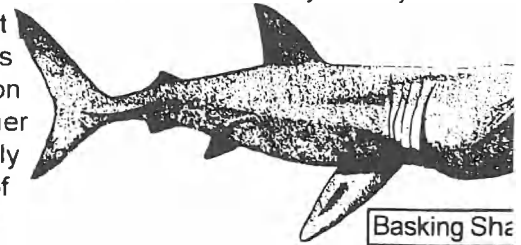


Many forms of plankton are the juveniles of some of our more familiar shore creatures, such as limpets, barnacles and crabs. These only live as plankton for the early stages of their life cycle. A sample of sea water taken close inshore in early summer will be full of both permanent and temporary plankton.

Fish, like plankton, tend to concentrate in certain areas. Many can be found in distinct stocks that have set migration routes at certain times of the year. The mackerel stocks found in the North Sea tend to concentrate on the seabed during winter, feeding on shrimps and small crustaceans. During the spring they move into surface waters and migrate to spawning grounds such as the central North Sea, Shetland and Norway. During the summer, they can be found all around the coast.

Along western and southern coasts, fish more commonly associated with warmer climates can be seen, brought to our waters by northerly currents from the warmer waters of the south. Wreckfish, tunny, sunfish and a variety of sharks occasionally turn up. The basking shark is the second largest fish in the world and can be spotted in British coastal waters every summer. It is a filter feeder, living entirely on plankton which

it strains out of the water through rakers inside its cavernous mouth. They occur off the west coast, especially the Irish sea, during early summer. Little is known about their lifestyle, and nobody is sure where they go during the winter or even how many actually exist.



Basking Shark

Grey and common seals are native to Britain. They have quite separate breeding seasons and breeding grounds around the coast. Grey seals prefer rocky shores and large breeding colonies can be found on the Farn Islands, the outer Hebrides and the south west of Wales. Common seals prefer sheltered estuaries; sandy areas such as offshore sand banks along the east coast.

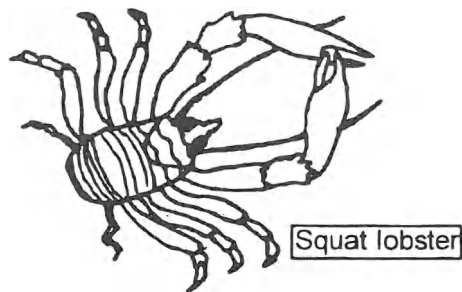
Cetaceans are just as much a part of British wildlife as badgers. However, people get the chance to view these special creatures close up. At least one cetacean species has been recorded around Britain, the majority just passing through as part of migration. The common porpoise is the commonest cetacean found in British waters.

Sea birds are a familiar sight at the coast. Many can only be seen in Spring, spending Winter far out at sea. Britain is very important for seabirds, with its inshore waters, estuaries and remote rocky islands. Sea birds rely on the coast for their food, and rely on the coast for nesting.

## Rocky Reefs

Rocky seabeds provide a large surface area for colonisation by a wide variety of plant and animal life. Some surfaces are so crowded that it is almost impossible to see the rocks beneath. Provided there is enough light and available nutrients, many large seaweeds thrive on hard rocky seabeds. Animals, such as sponges, anemones, hydroids (sea fans), bryozoa (sea-mats) and sea squirts also use rocky areas to take advantage of the large amount of food suspended in the water, taking in food by filtering or trapping. The presence of attached animals attracts more mobile creatures such as urchins, crabs, and fish looking for food.

habitats are widespread and provide food and shelter for a variety of marine life. At the base of the kelp, the holdfasts are often colonised by attached organisms and provide shelter for many small fish and crustaceans. The sea anemone is a common sight amongst the holdfasts. Fish such as pollack and other members of the cod family swim amongst the fronds whereas wrasse prefer to dart around the stipes (stems).



Squat lobster

## Sand, Gravel and Shingle Seabeds

Much of the seabed around the British Isles is dominated by mobile sands, gravels and shingle. Loose sediment (surficial) is easily moved by waves and currents, making it a difficult place to live. In the most mobile areas virtually nothing survives the grinding and crushing effect of sediments. However, where conditions are more stable, colonisation by encrusting organisms, such as sponges, sea-mats and sea squirts occurs. Barnacles and tube worms are typical colonists of the undersides of pebbles whilst anemones may find a home between pebbles. Rough ground may be colonised by huge colonies of brittle stars, with several thousand packed into several square metres. Fine sediments around pebbles provide a habitat for worms and small crustaceans. In shallow waters sediments are often covered by a carpet of red and green seaweeds.

Some areas of seabed are covered by shell fragments and may encourage the development of rich communities. Rather than attaching to the shells, organisms of shelly areas tend to be burrowers. However, mussels are able to colonise non-rocky areas of mixed sand and shell by clinging to fragments using adhesive byssus threads. The presence of one juvenile provides a stimulus for others to settle and eventually a group will form which will also encourage other species to move in; gradually a more complex community builds up. Weeds, hydroids, bryozoans and sea squirts can all find a relatively stable surface whilst tiny crustaceans can find shelter amongst the crevices.

## Soft Seabeds

Fine silts settle out in sheltered areas such as estuaries and lochs, and provide a home for a wide variety of animals. Most are burrowers. Bivalves such as cockles and razor shells make contact with the surface through siphons, while a few such as scallops live on the surface. Some segmented

worms can be seen crawling about on the surface too, but most tend to bury themselves in protective tubes, using tentacles to make contact with the surface.

Sand offshore is often subjected to strong tidal currents, and can build up into large banks and fields of sand-waves that constantly shift. The best known sandbanks around Britain are the Goodwin Sands, north of the Straits of Dover. The number of wrecks charted in the area signifies the hazard to shipping that these mobile features present. Much of the marine life in these areas is burrowing worm species, but brittlestars, hermit crabs, masked crabs, and flatfish such as plaice and sole also live here. Some areas provide nursery grounds for juvenile flatfish.

Where the seabed is made up of a mixture of fine and coarse sediments organisms can become attached, leading to a greater diversity of species. Colonies of mussels, worms and sponges form a large, stable mat of animals.

Artificial surfaces such as jetties, harbour walls, oil rigs and wrecks present surface areas for attachment. Where structures are placed on a soft seabed they will, given time, present relatively stable conditions which encourage hard bottom species to colonise an area where they may not naturally be present. Communities on these artificial reefs are quite different from the surrounding area and even the nearest rocky reef. A common feature of many artificial structures is that they often support dense shoals of fish.

## Threats to shallow seas:

This factsheet can only give a brief overview of some of the main threats to the marine environment. For further information refer to the MCS *Marine Conservation - A UK Action Guide*, and other MCS factsheets (see overleaf for contact details)

Shallow seas around Britain have always been important to the economic development of the nation. In recent years, the levels of exploitation and pollution have increased dramatically to a level which now affects the livelihoods and welfare of people, as well as marine wildlife. Unfortunately, it is always hard to see the damage being done to the marine environment until it has actually occurred.

shells provide steep rocky surface areas, so vertical changes in species distribution tend to be abrupt, with plant dominated communities nearer the top and animal dominated communities at the bottom.

Cracks and holes form important micro-habitats with very different communities because conditions are so different from the surrounding areas. Shaded and sheltered from water movement by large predators, they provide a home for animals such as worms, lobsters, sea-cucumbers and fish. Only inhabitants only venture out to feed while some feed on nutrients from the water that accumulates within the crevice, and some use their feeding apparatus beyond the hole in order to trap suspended particles or passing prey.

Soft rock such as chalk and clay support organisms adapted to burrowing such as the piddock, polychaete worms and boring sponges. Holes and burrows provide additional shelter for other animals, particularly anemones and lobsters. The activities of boring organisms can cause erosion whilst the grinding effect of water movement on the rocks can prevent most species from colonising.

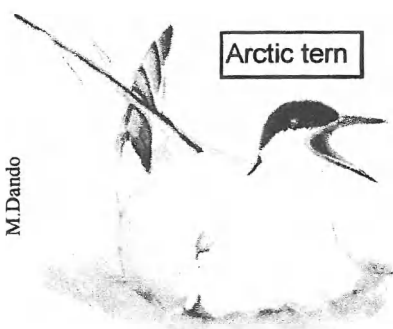


Kelp Forest

## Overfishing:

The North sea is one of the world's major fishing grounds, supporting a variety of commercial fish stocks. Pelagic fish taken are mackerel and herring, and demersal species such as cod, haddock, saithe and whiting are fished extensively. Bottom living fish, especially plaice and sole are also exploited. Some species are not taken directly for human consumption, such as Norway pout, sandeels and sprats, most of which are made into fishmeal for use in intensive livestock farming.

Rapid technological advances made in recent years have allowed the efficiency of fishing fleets to increase, and numbers of boats employed in fishing have increased in recent decades. Many species such as herring, cod, skate and haddock have been so heavily fished that their populations have fallen to critical levels. If the natural balance is greatly upset by commercial fishing there will be far reaching consequences on marine ecosystems. The possible links between sandeel fisheries and the breeding failure of seabirds, especially arctic terns and kittiwakes, are well documented.



Arctic tern

## Waste disposal:

Sewage effluent enters the sea directly from coastal towns via short sea and long sea outfalls. Significant amounts also enter the sea from rivers. Inorganic nutrients in sewage (nitrogen and phosphorous) can cause over-fertilisation resulting in algal blooms which can contaminate shellfish with toxins and present a danger to public health. Sewage also contains bacteria and viruses which are potential health hazards.

The presence of increasing amounts of plastic materials and dangerous and hazardous items on beaches and in our seas can have a serious effect on marine organisms. Seabirds, marine mammals and fish become entangled in marine litter

or may ingest plastic items mistaking them for food. Although discarding plastic waste into the sea from boats is prohibited under MARPOL V, the legislation is frequently disregarded.

Industrial waste reaches the sea from a variety of sources, including direct discharge, via rivers, through airborne means (aerosols and rain) and through accidental and intentional releases. Heavy metals such as mercury, cadmium, lead and tin are known to cause problems in marine organisms and may be bio-accumulated to harmful levels. PCBs (polychlorinated biphenyls) are very stable and persistent compounds. Their effects are difficult to assess but they may contribute to the death of marine animals, particularly if the animal is already under stress. Some chemicals, such as tributyl tin (TBT), disrupt the hormone balances of organisms, causing gender alterations and infertility.

Radioactive waste was first released into the sea in the 1940s. Most nuclear plants in Britain are at or near the coast, Sellafield being the major contributor of radioactivity to British waters. Low level radioactive wastes are disposed of by direct discharge into the sea. The cumulative effects on marine wildlife have proved difficult to assess and the Chernobyl incident highlighted the lack of knowledge on environmental and biological effects of radiation, particularly on marine organisms.

Oil enters the sea from a number of sources - accidents at the well-head, equipment failure on the production platform, shipping accidents, illegal discharge during tank washing, pipeline damage and from the domestic sewerage system. When oil enters the sea planktonic organisms are usually the first affected which in time affects whole biological communities. Sea mammals, sea birds and shore life may be directly affected to varying degrees, depending on the nature and extent of the spill, the state of the sea and the type of coast that has been affected.

## Coastal development:

The coastal zone supports many activities, including shipping industry, housing and recreation, and the impact may extend well into the sublittoral zone. Harbour construction and reclamation has accounted for

substantial habitat loss, particularly in estuaries. Construction may lead to changes in water movement, turbidity and sediment deposition, which in turn will affect benthic communities. At present, activities within the coastal zone tend to be carried out in isolation, there being over 30 Government departments with responsibilities in the coastal zone. Even where projects do include an environmental impact assessment, there is no guarantee that the recommendations will be acted upon. Added to this there are still gaps in our knowledge of certain elements of the marine ecosystem so that accurate predictions of the likely impact of an activity are difficult.

## What you can do to help:

(i) Please join the Marine Conservation Society and support our campaigns to protect the marine environment for wildlife and future generations.

(ii) Take part in surveys and projects organised by the Society such as Beachwatch, the basking shark survey and Adopt-a-Beach (send a large SAE for further details to the address below).

(iii) Learn more about the marine environment. MCS Sales stocks titles suitable for all ages and all levels of interest. You can find out more from libraries, museums and visitor centres.

**Marine Conservation Society**  
**9 Gloucester Road**  
**Ross-On-Wye**  
**Herefordshire**  
**HR9 5BU**

**Tel: 01989 566 017 Fax: 01989 567 815**

[www.mcsuk.org](http://www.mcsuk.org)

[www.goodbeachguide.co.uk](http://www.goodbeachguide.co.uk)



**THE MARINE CONSERVATION SOCIETY (MCS) IS THE NATIONAL UK CHARITY DEDICATED TO PROTECTING THE MARINE ENVIRONMENT & ITS WILDLIFE**

# ESTUARIES

MUDDY WASTELANDS FOR RECLAMATION, PLAYGROUNDS FOR PEOPLE, OR HAVENS FOR WILDLIFE? ESTUARIES ARE AN IMPORTANT PART OF OUR NATURAL HERITAGE, BUT THEY ARE AN EASILY DAMAGED RESOURCE FACING LONG TERM AND CONTINUOUS PRESSURE FROM HUMAN ACTIVITY. THE NUMBER OF ACTIVITIES GOING ON IN AN ESTUARY - SHIPPING, WATERSPORTS, FISHING ETC. - MEANS THAT MANAGING THEM FOR CONSERVATION CAN BE DIFFICULT, BUT THEIR WILDLIFE VALUE IS UNDOUBTEDLY GREAT.



## What is an Estuary?

An estuary is a wetland that forms where a river flows into the sea. Generally, estuaries may be described as partially enclosed areas of water, receiving freshwater from rivers and open to the saline waters of the sea. They are features of the land/sea interface, and are dynamically complex areas constantly undergoing changes in salinity, temperature and turbidity as a result of fresh and salt-water mixing. Because of this unique variation in physical, chemical and biological conditions, inhabiting organisms must adapt to them to survive. They must also tolerate variable salinity, and exposure and immersion during the tidal cycle. But because their sediments are incredibly rich in nutrients, estuaries can support large numbers of animals, especially invertebrates, birds and fish, making them areas of great conservation importance. Although species diversity is often small, populations are usually found to be very large.

Most of Britain's estuaries formed during the gradual rise in sea level since the last Ice Age (about 10,000 yrs. ago). Being systems of extremes, they support a variety of subtidal, intertidal and terrestrial habitats including mudflats, rocky shore, sandflats, saltmarshes, lagoons, sand dunes and grazing marshes. Estuaries of most significant nature conservation value display a range of habitats and aquatic communities.

## Physical characteristics

Four main physical features are important in estuarine systems:

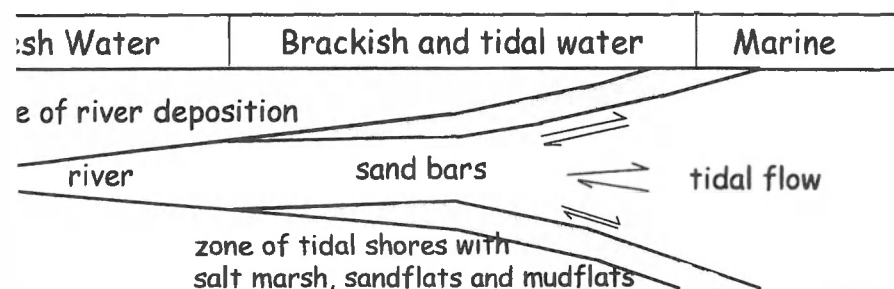
### Salinity

Estuaries are places where both salt and freshwater mix, so salinity fluctuates daily with the tidal cycle as well as seasonally. A salinity gradient can be mapped between the head and mouth of the estuary, and vertically through the water column. Gradients depend on the

amount of freshwater input - heavy rainfall causes dilution, pushing gradients seaward, whilst in dry periods, saline water pushes up river. Large freshwater inputs also create vertical layering, as less dense freshwater floats above seawater, making a what is known as a *salt-wedge*.

### Sedimentation

Estuaries often contain a large amount of suspended sediment derived both from the seabed and river catchments. Deposition of this material is influenced by both tidal and river currents. Sheltered conditions allow the sediment to settle, creating expanses of intertidal mudflat. In more exposed areas, such as the estuary mouth, only large particles of sediment such as sand and shingle will settle, forming beds of loose conglomerate. In the very sheltered upper reaches, where water movement is sluggish, fine particles of silt and mud gently settle out to form soft but dense mud.



At the head of the estuary, fast flowing river currents keep fine particles suspended, however, due to the mixing of salt and fresh water, clay particles still attract each other producing clumps that quickly settle out. This process is known as **flocculation**.

This gives a characteristic gradation of particle size throughout the estuary. Mudflats are constantly changing, often short-lived features (in geological terms). Continuous sedimentation eventually ensures succession from intertidal flat to saltmarsh (and eventually dry land) over 100 years or more.

### Tides

Tides have great influence on estuarine environments, governing the lives of all inhabitants. Tidal range varies according to location; the Bristol Channel (Severn Estuary) has the second highest tidal range in the world (12m), whereas a south coast estuary may experience average tidal rise and fall of less than 2m. Large expanses of intertidal flats are exposed at low water, and organisms that inhabit these must withstand exposure or be able to burrow into the sediment away from extremes of temperature (and hungry predators!).

### Nutrients

Tidal cycles bring continuous supplies of fresh nutrients to estuaries, making them some of the most productive ecosystems on Earth. Detritus from sea and river catchments is the major nutrient resource, supporting huge populations of deposit and suspension feeders - molluscs, crustacea and worms which in turn form the diet of many predators such as fish, birds and humans!

## Estuary Life

### Mudflats

Life on, and within, **mudflats** is harsh. But those species which can withstand fluctuations in conditions find an abundance of food, and a relative lack of competition. Organisms have developed strategies to cope with changes in salinity. Most regulate body fluids, others burrow into sediments where salinity is more stable, whilst shellfish simply close their shells and shut the world out. Soft mud is easy to burrow in, and the **Baltic tellin** is commonly found beneath the surface. Its only connection with the surface is its siphons which filter organic material from the water, but it also feeds directly on the mud using a siphon as a 'vacuum cleaner'.

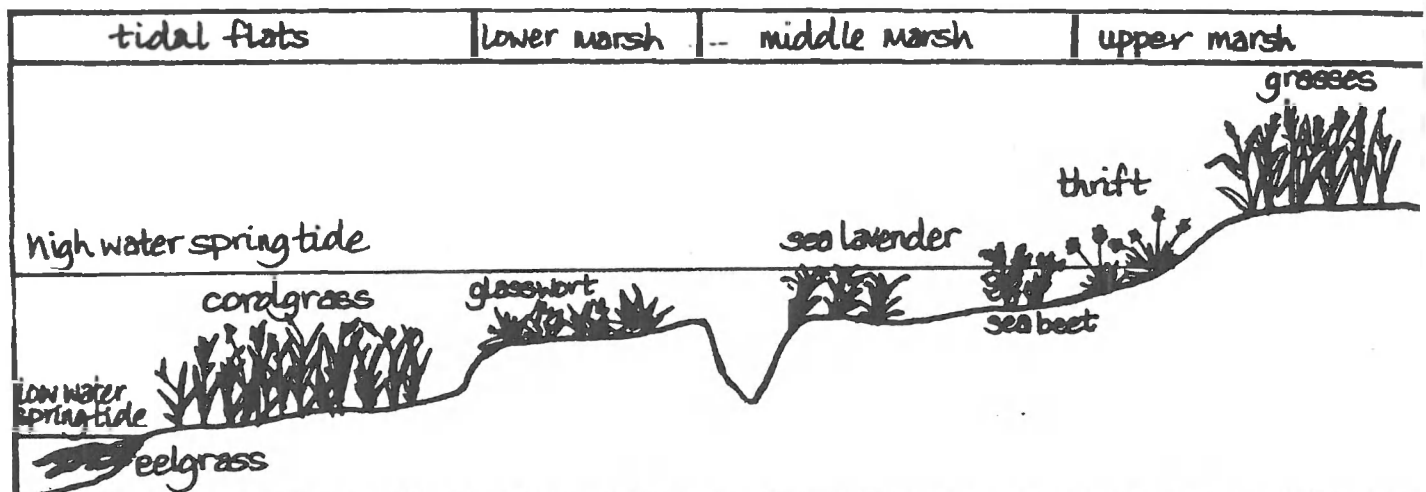
The **sandhopper** hides in a u-shaped burrow when the tide is out. As the tide comes in, it emerges to crawl over the surface in search of food. When the tide is out the surface of the mud may be thick with tiny, grazing snails called **Hydrobia**. The **lugworm** and **ragworm** are probably the best known inhabitants of intertidal flats, but display very different lifestyles.

The lugworm lives most of its life in its burrow, eating organic parts of the mud that it lives in, ridding waste as the familiar worm-cast. The ragworm is far more active, reaching out from its burrow to scavenge food.

### Saltmarsh

**Saltmarshes** may form in estuaries, providing a home to low-growing plants and animals, and acting as a year-round bird-feeding ground. They are sheltered sites of *alluvial* (river-derived) deposits, colonized by salt-tolerant plants, and frequently inundated with seawater. Saltmarsh is, in effect a transitional stage between tidal flat and terrestrial habitat. Salt-tolerant plants in mudflats first trap mud and silt. Gradually, sediment builds up, and as the mud surface rises, saltmarsh develops growing outwards from the land. The seaward edge is marked by the lowest high tides (during neaps which occur twice a month).

Saltmarsh formation depends on the degree of shelter and the amount of sediment available. The edge of the saltmarsh is where all the action occurs; most sedimentation occurs during summer, whereas erosion may take place during winter when storm conditions prevail.



**Fish**

The abundance of invertebrates in mud make estuaries important habitats for fish. They are also used as migration routes for breeding and spawning. Some fish remain in estuaries all their lives, others just for part of their life-cycle. Truly estuarine species include the **sea bass**, **common goby** and **golden mullet** and they depend on estuaries for their complete life cycle. Some fish, such as **flounder**, are able to move between sea and fresh water, whilst **salmon** travel through estuaries from the sea to rivers to breed. Sheltered estuaries such as the Humber and Wash are important nursery areas for flatfish, whilst many estuaries on the south coast are sea bass nursery areas.

**Birds**

Britain's estuaries are of national and international importance for migrant and over wintering waterfowl. Mudflats, sandflats, and saltmarsh are used for feeding and roosting, and because Britain's estuaries rarely freeze over for any length of time, they are particularly important during winter. The Ribble, Colway, Tamar, Humber and Wash, for example are vital to huge numbers of waders such as **odwit**, **dunlin**, **curlew**, **ystercatcher** and **redshank**. Many migratory birds depend on them as refuelling stations between Arctic breeding grounds

and African wintering areas. Thus, estuaries form an important network of feeding stages, and many species use estuaries for breeding too.

**Plants**

Few plant species can tolerate estuarine conditions, but eelgrass and algae play a vital role in trapping sediment, preventing erosion and providing food. Such vegetation is well adapted to salty conditions. Plants occur in zones, the more salt tolerant ones nearer the sea. The low marsh zone (nearest the water's edge) is also termed the *pioneer zone*, and contains species that stand submergence such as **cord grass**, **glasswort** and **sea aster**. Glasswort is one of the first settlers, its fleshy stem and branches retaining moisture well. Cord grass can establish where stronger currents prevail due to a very strong root system. Common cordgrass is a hybrid between native and American varieties. It has invaded many saltmarshes, first appearing in Southampton Water in the 19th century. Its ability to trap silt has led to its widespread use for land reclamation, and it can also smother slow growing species near the lower shore causing loss of tidal feeding grounds for birds.

The middle marsh exhibits most diversity because high spring tides deposit seeds and nutrient-laden silt. Look here for **sea lavender**, **sea arrow grass** and **saltmarsh grass**. On the high marsh, **sea beet** and grasses such as **sea couch** predominate. Given time, and under natural conditions, a high marsh grades into woodland.

**Threats from human activities**

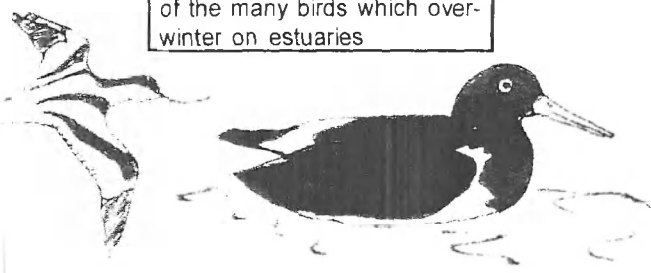
*An estimated 18 million people live in towns and cities around Britain's estuaries. Coastal development continues at an alarming rate with the expansion of urban areas and industry. Increased human activity is causing concern amongst conservationists.*

**Pollution**

Pollution has been caused by widespread and continual discharge of waste into estuaries, and just adds to the perception of estuaries as wastelands of foul smelling mud. Inland activities also add significant amounts of waste via run-off into the river catchment area. Organic effluent such as domestic sewage is a serious problem - the discharge of small quantities of sewage into estuarine systems can actually increase the productivity of the ecosystem, but excessive quantities will deplete oxygen, causing widespread destruction of plants and animals.

Domestic sewage also contains industrial waste with its large load of heavy metals, which can be toxic at low concentrations. Animals that filter food from the water tend to accumulate these. When the organisms are eaten by predators further up the food chain (including humans), the concentration will be magnified. Heavy metals also tend to attach themselves to suspended sediments which settle out.

Avocet & oystercatcher - two of the many birds which over-winter on estuaries



## ★ Recreation

The increase in recreational activity around estuaries has increased and added to the problems already faced by wildlife and habitats. Yachting, water skiing, windsurfing, angling, canoeing, birdwatching, jet-skiing and walking are just some of the activities practiced on and around our estuaries. The obvious impact of all of these activities is disturbance. Many water-based sports were, at one time, restricted (by weather and water temperature) to the summer months. Recent developments in watersports clothing have now extended the season for many, and they have now become year round pursuits. This is of particular concern when waterfowl are breeding or over wintering at a site, and regular disturbance can make areas of the shore permanently unusable. The surge in the number of marinas being built around the coast is of concern, because they involve not only the direct loss of mudflat habitats but also have a knock on effect on adjacent areas. The wash from boats will increase the erosion along the edge of the saltmarsh as well as disturbance to birds.

**Bait digging** has increased in many estuaries due to the increased popularity of sea angling. Lugworms and ragworms make the best bait, and digging

for these can have serious effects on the shore. Resultant pits and trenches are dangerous to other users, the populations of species may be severely reduced, non-target species may accidentally be removed, feeding waterfowl may be disturbed, and pollutants buried in the sediment may be released.

## ★ Land claim

Land claim is still occurring in a piecemeal and fragmented fashion, but at an alarming rate. Small scale land claim may seem insignificant, but accumulative effects over time are substantial. In the past, much of the reclamation has been for agricultural purposes, but today, housing schemes, marinas and barrage schemes account for the majority of developments.

## ★ Global warming & sea level rise

It is generally accepted that the consequence of global warming will be a rise in sea level which will affect low-lying, estuarine areas. Britain is still readjusting from the last Ice Age with land in the south still sinking. A further rise in sea level, induced by global warming, will add to the impact, pushing estuaries and intertidal areas landward. If allowed to respond naturally to these conditions, estuaries would adapt slowly.

However, much of the coastline is now "fixed" by man-made coastal defences along the saltmarsh edge. One solution is to actually remove parts of the existing sea defences and let the coast retreat naturally, allowing habitats to re-establish, in a **Managed Retreat**.

## Estuary Conservation

The need for *coastal zone management* (CZM) for the whole coast is widely accepted in the U.K. and model strategies are now being prepared. As our estuarine resource continues to be depleted, conflicts between user groups and with nature conservation increase. For successful management, it is important that estuaries are viewed as ecological units, and not by administrative boundaries - estuaries are often the boundary between counties or even countries e.g. the Severn, Dee and Solway Firth. The majority of estuaries now have management plans and strategies written for them. These need to be successfully implemented to save our estuaries and wetland habitats.

### How YOU can help 1

Join the Marine Conservation Society and support our work

**Marine Conservation Society**

**9 Gloucester Road**

**Ross-On-Wye**

**Herefordshire**

**HR9 5BU**

**Tel: 01989 566 017 Fax: 01989 567 815**

**www.mcsuk.org**

### How YOU can help 2

Support your Local Estuary Management Scheme:

**Moray Firth Partnership**

Tel. 01463 712221

**Solway Firth Partnership**

Tel. 01387 247010

**Severn Estuary Conservation Group** Tel. 01222 874 000

**Solent Forum**

Tel. 01962 846027

**Tamar Estuaries Initiative**

Tel. 01752 668000

**Wash Estuary**

Tel. 01775 761161

For information on other estuaries around the UK, contact MCS or

Countryside Council for Wales

Tel. 01248 370 444

English Nature Tel. 01733 455 000

Scottish Natural Heritage

Tel. 0131 447 4784



CORAL REEFS ARE UNIQUE STRUCTURES BUILT BY RELATIVELY SIMPLE MARINE ORGANISMS. THEIR STRUCTURAL COMPLEXITY, TOGETHER WITH HIGH BIODIVERSITY AND PRODUCTIVITY MAKES THEM EXTREMELY IMPORTANT.

# Coral Reefs



MARINE CONSERVATION  
SOCIETY

FACTSHEET

## THE LIVING REEF:

Reefs are of great value for subsistence and commercial fisheries, providing a wide range of species for food, decorative and medicinal purposes. The fish yield can be as high as 30-40 tonnes/sq/m/yr, although in many reef areas it is around 4-6 t/sq m/yr [variability reflects differences in fishing methods, effort, type of reef, species targeted etc].

The reef structure itself acts as a natural breakwater, protecting adjacent coastal lands from the full force of the sea. Coral reefs are also important recreational areas, for example a million people visit the Great Barrier Reef annually.

Reefs are vulnerable to damage because the corals which form their basic structure have very specific requirements. They need clear water for the single-celled algae [*zooxanthellae*] within their tissues which, like other plants, photosynthesise using energy from the sun. Although corals catch some food with their tentacles, they rely to a large extent on material manufactured by the zooxanthellae. If the water is turbid the zooxanthellae cannot function efficiently - and so the corals suffer.

Corals also need a small temperature range, good water circulation and minimal sedimentation. They are easily stressed by adverse conditions and even if not killed, their growth and metabolism may be affected, and they may be more vulnerable to disease, storm damage and other influences.

## 'Natural' damage to reefs:

The reef ecosystem is highly complex, with community structure governed by many interlinking biological and environmental factors. It is a dynamic system, and probably less stable and fragile than originally thought. It has been shown that healthy reefs have the capacity to withstand or recover from certain 'natural' events, and that this disturbance may in fact help to maintain high diversity.

However, it is important to recognise that not enough is known about some of these so-called 'natural' events. In some cases it may transpire that human activities have a considerable influence on their occurrence and severity.

### (i) Hurricanes and storms:

Some naturally occurring events, particularly hurricanes and storms, can have as much of an impact on reefs as man-made activities and events such as mining or boat grounding.

● After Hurricane Allan had passed through Jamaica in 1980, an estimated 95% of staghorn coral (*Acropora cervicornis*) was destroyed on many reefs.

### (ii) Coral predators:

Coral skeletons are eroded by the burrowing activities of a wide range of reef organisms (particularly bivalve molluscs, worms and sponges) and the coral polyps themselves are attacked by many predators. Both eroders and predators have a significant impact on reef structure

and development particularly if erosion or predation is at an 'abnormally' high level.

The most notorious predator (occurring only on Indo-Pacific reefs) is the crown-of-thorns starfish *Acanthaster planci* which sometimes occurs in plagues and destroys large tracts of reef or even entire reefs. The arguments about the cause of the outbreaks continue, but humans may well be implicated, for example through over-harvesting of the starfishes normal predators, or by creating conditions which enable greater numbers of starfish larvae to survive (such as increased nutrient levels from sewage encouraging phytoplankton growth which in turn provides more food for the developing larvae).

### (iii) Diseases:

Corals are affected by a number of diseases, particularly white band disease (believed to be caused by bacteria) and black band (the cause of which is still not entirely understood). Both of these may lead to death of the affected corals. These diseases were first reported in the late 1970s from the Caribbean, where their effects have been most severe, but in recent years they have been reported from localities throughout the tropics.

Other reef animals also suffer from diseases. Sea urchins in the Caribbean have been particularly badly affected, possibly by a water-borne bacterial pathogen.

#### (iv) Coral bleaching:

The past decade has seen a decline in the health of corals on a global scale that is causing considerable concern. One of the most serious problems is the loss (or expulsion) of the zooxanthellae that live in the coral tissues. This happens when corals are stressed and is known as bleaching. Corals can recover from bleaching and regain their zooxanthellae, but it seems that the frequency and severity of 'bleaching events' is increasing, leaving little time for the corals to recover between each event.

● Around islands off Java (Indonesia) coral mortality followed bleaching, with live coral cover on some reef flats reduced from about 50% to less than 1% in a few months during early 1983; fortunately the corals recovered later.

The first world-wide bleaching was in 1982/83, coinciding with a severe El-Nino event [abnormal pattern of climate and water movement] in the southern Pacific. The second was in 1987-1988. Bleaching is thought to be due to prolonged, small temperature increases; perhaps connected with global warming and related human-induced climatic change, or to natural climatic events. It can also be caused by a variety of other impacts such as pollution, freshwater run-off, low water temperature and prolonged exposure to air.

#### (v) Sea level rise:

If, as predicted, sea levels rise in response to global warming, it will be disastrous if the corals have died back and reef growth declines. Healthy reefs will probably keep pace for the next 50 years or so, but low-lying island nations such as the Maldives may ultimately be at risk if the islands lose their protective barrier of living reef.

#### Human Impacts:

In common with virtually every natural habitat, coral reefs have been degraded and in places destroyed by human activities. An analysis carried out in the mid-1980s by the *International Union for the Conservation of Nature* showed that 93 out of the 109 countries with reefs had suffered damage from human activities.

#### (i) Water turbidity and sedimentation:

Many reefs have been badly affected by sediments carried to the sea in rivers, piped into the sea (e.g. sewage), washed directly from the land or stirred up from the seabed (e.g. as a result of dredging). Fringing reefs are particularly vulnerable to land-based sources of sediment, much of which consists of soil eroded from land which has been logged, mined or cleared for housing, recreation, industry or agriculture.

● A case study in the Philippines showed that the erosion rate from cut forest in one of the islands was over 4 times greater and from roads 240 times greater than erosion from virgin forest.

Sediments cause two problems:

(a) turbid water

(b) deposition of fine material on the seabed.

Turbidity inhibits photosynthesis by the zooxanthellae, and thus slows coral growth itself. Sediments smother corals, and although some species are resistant to moderate amounts, others are killed. Sediments also stop coral larvae settling and turning into adult corals. This causes significant changes to the ecology of the reef.

#### (ii) Pollution and nutrient enrichment:

Pollution from industrial and domestic sources tends to be highest around fringing reefs close to highly populated areas, although pollutants such as oil also come from activities (or accidents) at sea. As far as oil pollution is concerned, it appears that, even though reefs may suffer little (e.g. reefs in the Gulf were undamaged by oil spills in 1991), there may be much longer-term effects from toxins that are in the water or leach from sediments where oil has settled.

● Reefs in Panama were very badly damaged by an oil spill in 1986. Corals suffered 90% mortality on some parts of the reef and, in 1991, had still not recovered.

Probably the greatest impact overall is from excessive inputs of organic matter such as sewage. The resulting high nutrient levels encourage algal

growth to such an extent that the corals may be overgrown.

● In Kaneohe Bay in Hawaii, construction of a sewage outfall in 1963 led to corals being smothered by explosive growth of green algae. Only when public pressure resulted in removal of the outfall in 1978 did the corals begin to recover.

#### (iii) Coral mining and dredging:

In several countries (e.g. Maldives, Sri Lanka and India) coral is mined from living reefs for use as a building material. It may be used in the form of blocks, crushed to make aggregate or fired to produce lime. Coral mining is a destructive activity because it affects the framework of the reef and causes habitat degradation.

● In the Maldives live coral cover on mined reefs was found to be only 1%, in comparison with 11-60% in unexploited areas. Furthermore, although a little regeneration occurred at some of the sites, at many others there was minimal recovery after 10 years.

Coral sand is also dredged in large quantities for the construction industry, particularly from back reefs. This may cause increased turbidity and altered current flow (so affecting living corals), and will almost inevitably lead to increased coastal erosion.

#### (iv) Coastal construction:

Coastal lands are often considered prime sites for industry, housing and recreation. The clearance and infilling that accompanies development tends to cause increased turbidity and sedimentation. Sometimes reefs are entirely destroyed by being built over.

Construction of harbours, jetties, sea walls and other coastal structures, unless carefully sited and constructed, can change water circulation over adjacent reefs, which is a critical influence on corals and other reef organisms.

● At Biyadhoo in the Maldives the construction of two solid (coral) jetties led to sand being trapped on the reef top and then cascading down the reef front, suffocating the corals.

## **(v) Exploitation of living reef resources:**

### **(a) For food:**

A wide range of edible species is utilised for local consumption or export. Intensive fishing has led to declines in fish catches in many inshore reef areas. Snappers, groupers and other large, high value fish have been particularly badly affected. Once staple foods in regions such as the Caribbean, they are now fished mainly for the export market and tourist industry. Spiny lobster and Queen Conch have been similarly affected.

● In the Pacific the giant clam has been seriously overfished (to the point of extinction in some islands) to satisfy the demand for clam meat in restaurants in Asia.

Overfishing not only depletes stocks but can upset the ecological balance on reefs. Removal of herbivorous fish such as parrotfish and surgeonfish can lead to overgrowth of seaweed on a reef; overfishing of predatory fish such as groupers can cause increased populations of herbivorous animals and subsequent overgrazing.

● Overfishing of triggerfish and puffer-fish (among the few fish to feed on sea urchins) is thought to be responsible for some of the urchin outbreaks that have caused damage to corals (urchins graze on fine algal films that grown on reefs, and in doing so, erode the corals).

An added problem is that some of the fishing methods damage the reef habitat, for example, the use of large traps and 'beating' of corals to frighten fish into nets. 'Fishing' with dynamite is particularly destructive, and although illegal, is still carried on in countries such as Tanzania and the Philippines.

● Studies in the Philippines suggest that it will take about 40 years for reefs to recover (to 50% coral cover) from destruction by dynamite-blasting, and that destructive fishing has reduced the productivity of reef fish by at least 37% in the past 20 years.

### **(b) For the curio and aquatic trade:**

A wide range of reef animals, but especially shells and corals are collected for use as curios. Domestic and international trade amounts to thousands of tonnes annually from all over the tropical world. In addition, many animals are taken live for the aquarium trade.

● Official statistics show that in 1989 Singapore alone exported over four and a half million marine aquarium fish.

Populations of certain reef species are known to have been depleted in areas where collecting pressure is high, and ecological disturbances as described above can also occur. Rare species are particularly vulnerable, but populations of previously common and widely distributed species such as the giant clam (taken mainly for their meat) have been seriously depleted in countries such as Indonesia and the Philippines as a result of the shell trade and industrial use.

● In New Caledonia, reef corals are being harvested for the curio trade at what has been calculated to be ten times the sustainable rate.

### **(vi) Recreational use**

Reef tourism brings benefits such as employment and foreign currency to coral reef countries, together with an awareness of the importance of maintaining the reef in a healthy condition. However, as reef tourism increases, the dangers from trampling, littering, anchor damage and boat grounds increase. Additional tourist demands, for example for seafood and accommodation, bring further stresses.

● Before mooring buoys were established in the US Virgin Islands National Park, nearly half of the 30,000 boats that anchored in the park each year caused damage to the reefs and seagrass beds.

● Over 75,000 dives are made each year at the four most popular dive sites in Ras Mohammad Marine Park in Egypt; these sites have significantly more broken and dead coral than less frequently dived sites.

## **CONSERVATION AND MANAGEMENT:**

Considering the vulnerability of reefs and the range of impacts to which they are subjected, it is clear that national and international action is required to maintain the health, and productivity and biological diversity of reefs, while allowing sustainable use of their resources. There is a range of management options available, including designation of marine protected areas, protection of particularly rare or vulnerable species, fishery controls and measures to reduce or eliminate damage from coastal development and pollution.

### **(i) Reef protected areas:**

Designation of protected areas, is not an answer to all the problems, but helps focus attention on particularly important reefs and allows introduction of relevant conservation measures. Around 300 reef protected areas have been designated and at least twice that number proposed. Unfortunately it is difficult to protect them from pollution and silt derived from outside park boundaries.

The aim is to establish a form of management relevant to the particular features, values and uses of the reefs concerned. Normally a system of zoning is introduced, which attempts to reduce conflicts and minimise environmental damage by permitting specific activities only in designated areas.

Critical habitats or areas where rare species live may be designated as sanctuary areas where human intrusion is limited to occasional visits by scientists to carry out non-destructive research. In less vulnerable areas various activities are allowed (general use zone, wilderness zone, recreational zone, fishery reserve etc) although still within strict limits as laid down in the management plan.

The Great Barrier Reef Marine Park is perhaps exceptional in that sufficient financial resources and skilled manpower are available to implement and enforce a complex zoning system. However, it provides a very useful model and the general principles of its management can be applied elsewhere.

## **Management of living reef resources:**

Exploitation of reef species is usually controlled within marine protected areas, but it is equally important to develop fishery management plans for heavily-exploited species in other areas. Most countries have national legislation to regulate fisheries, but only selected species are covered.

Enforcement of fishery regulations is often difficult, due to lack of manpower, resources and commitment. In many areas it is proving more successful to set up community-based fishery (or other) reserves run by local people who benefit directly from successful management.

Mariculture can help in the conservation of living reef resources. For example, giant clams, lobsters and conch have been cultivated until ready for harvesting, and have also been transplanted to re-seed depleted areas. Some anemonefish and other reef fish are captive bred for the marine aquarium trade, thus reducing pressure on populations in the wild.

Rare or vulnerable reef species are protected in some countries through domestic legislation. International trade in marine turtles, giant clams, black corals and reef corals is monitored through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Under CITES, international trade in turtles is prohibited, and trade in clams, black corals and reef corals can be carried out only under licence.

The need for an integrated approach: Ultimately, successful coral reef protection and management depends on coastal zone management in its broadest sense, taking into account protection of watersheds, controlled coastal planning and sustained utilisation of reef and associated marine resources.

## **The Marine Conservation Society 'LET CORAL REEFS LIVE' CAMPAIGN**

The Marine Conservation Society recognises the international

importance of coral reefs and is working to protect them through its Let Coral Reefs Live campaign.

The main objectives are to:

- (i) increase public awareness of reef conservation issues
- (ii) reduce impacts caused by trade in reef species
- (iii) undertake practical reef conservation projects overseas

### **PUBLIC AWARENESS:**

Education plays an important part in the Let Coral Reefs Live campaign, and MCS has had a wide range of articles about reefs and their conservation published in the popular press. MCS also regularly provides information on reef conservation issues to a wide range of people and organisations.

In 1991 MCS launched a 'Visitor's Code' leaflet which is being distributed by tour operators and displayed at dive centres overseas. MCS has provided the raw material for a marine conservation display at a public aquarium in Singapore which concentrated on coral reefs and is assembling materials for similar displays in the UK.

### **TRADE IN REEF SPECIES:**

#### **(i) Living specimens for marine aquaria:**

MCS has produced the only comprehensive report on conservation aspects of the tropical marine aquarium trade from a UK perspective. This includes recommendations on management and has been widely distributed both in the UK and overseas. Subsequently, MCS was asked to investigate the possibility of introducing an 'eco-labelling' scheme for exotic marine species. This project is currently underway (funded by the World Wide Fund for Nature) as part of a continuing programme to bring about improvements in the marine aquatic trade.

#### **(ii) Corals, shells and other curios**

MCS published a technical report on marine curios in 1988, and is recognised as the leading authority in the UK on the trade and associated conservation issues. In 1989 MCS successfully lobbied for tighter controls on international trade in corals, and persuaded one of the major high

street stores in the UK to cease trading in reef animals. The Society produced a leaflet aimed at the buying public (Tempted to Buy Marine Souvenirs: Please Don't) which has been widely circulated, with requests for supplies continuing to come from overseas governments and conservation organisations.

Following several surveys of outlets selling marine curios, MCS published in 1991 a booklet entitled *The Marine Curio Trade: Conservation Guidelines and Legislation*, which is being distributed mainly to traders in the UK. MCS has worked closely with HM Customs and Excise during recent seizures of illegally imported corals, and will continue to campaign for better controls and more effective monitoring throughout the curio trade.

### **REEF CONSERVATION OVERSEAS:**

MCS plays an active role in the Forum for Conservation Action in UK Dependent Territories' and has links with many people involved in reef conservation work overseas.

MCS is running a coral reef educational project in the Turks and Caicos Islands (British West Indies) and is developing a number of other projects elsewhere, including a programme of reef research in the British Indian Ocean Territory.

### **WHAT YOU CAN DO:**

Although coral reefs do not occur here, there are several ways you can help:

● Support the MCS Let Coral Reefs Live Campaign. MCS is the only voluntary organisation in the UK with a specialist group working specifically to protect coral reefs.

● Join the Society and send a donation for the coral reef campaign.

● Help minimise trade in reef life. Reef animals are collected live from the wild to be sold dead, as souvenirs. You can help by resisting the temptation to buy them, particularly corals and any shells or other animals advertised as rare.

● Treat coral reefs with respect. If you go snorkelling and diving on reefs take great care. Corals are living animals and are damaged even by gentle handling. Please don't hold on to them, rest on them or kick them.

SKYSCRAPERS BUILT BY HUMANS PALE INTO INSIGNIFICANCE BESIDE STRUCTURES CREATED BY CORALS. SOME REEF SYSTEMS ARE SO HUGE THEY CAN BE SEEN FROM OUTER SPACE!

# CORAL REEF CONSERVATION

## Giant structures built by tiny organisms.

Many reefs stand thousands of metres above the sea-floor, although only the top metre or so is alive. The rest consists of coral skeletons and the remains of other animals and plants cemented together with sand.

Corals are simple animals like anemones, yet they build reefs of great complexity.

## Why so important?

- They are one of the Earth's greatest wonders. Who are we to disrupt millions of years of evolution?
- Reefs and their inhabitants play a vital role in the functioning of other natural systems.
- Reefs act as natural breakwaters, protecting adjacent land from erosion.
- They are very productive systems, providing millions of people with fish and other reef produce.
- They are beautiful, interesting and exciting places to visit. Income from tourism helps the economy of many nations.



## Reefs in trouble

● Unlike humans, corals cannot move from an area that becomes difficult to live in. When the water is dirty and polluted they become covered in sediment and may die. Other animals attached to the reef suffer in the same way.

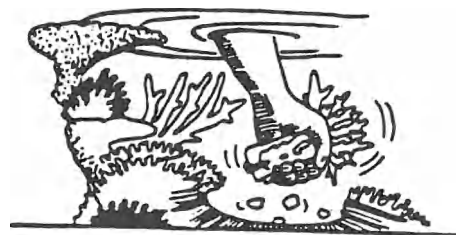
● Sewage and other organic material that wash into the sea can completely change coral reefs. They act like fertilisers and encourage seaweed growth, sometimes to such an extent that corals become overgrown.

● Corals are slow growing and if damaged or removed may take years to recover or be replaced. Reefs are badly damaged when *mined* for coral to be used as a building material. In some countries *dynamite* is used to catch reef fish. This is very destructive.

● Harbours, jetties and sea walls are sometimes built so close to reefs (even on top of them) that the *environmental conditions* are totally changed and the corals and other reef plants and animals cannot survive.

● Reef tourism brings benefits such as employment and foreign currency to many countries, but the reefs suffer from trampling, littering, anchor damage and boat groundings.

● Healthy reefs teem with life, but all too often they are overfished. Fish and shellfish are taken for food and many other animals are collected live for the aquarium trade or are killed and dried to make 'marine souvenirs'.



● Various animals prey on corals, but when it occurs in plagues, the crown of thorns starfish has the most devastating effect. Huge areas of coral are killed. Whether or not human activities help cause the outbreaks is unknown.

● Although corals live in tropical waters they become stressed and 'bleach' white if the temperature of the sea increases. Bleaching sometimes kills the corals and may possibly be connected with global warming.

● In recent years corals have been badly affected by disease. Coral disease is most common in the Caribbean, but has also been found in other tropical localities. Corals may be killed and large areas of reef affected.

## Conservation:

The challenge is simple. We have to prevent reefs from further damage. This does not mean we have to stop using them, just that we have to manage them and their rich resources very carefully.

### Reef Parks and Reserves:

Marine parks and reserves help to protect very important reefs. Around 300 parks and reserves have been set up and at least twice that number proposed. Normally a system of Zoning is introduced, which permits particular activities in specific areas (e.g. general use zone, wilderness zone, recreational zone, fishery reserve etc). The Great Barrier Reef Marine Park in Australia is a good model of such a system.

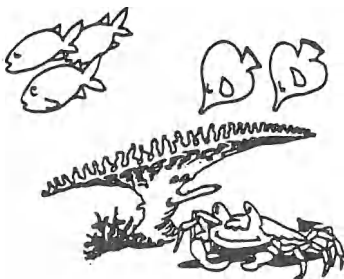
### Management of living reef resources

*Fishing and exploitation* of reef animals is usually banned or controlled within marine parks and reserves. It is equally important to control these activities in other areas. Many countries have laws to prevent over-fishing and collection of reef animals such as lobsters and shells, but other species are not protected at all.

*Enforcement* of fishery regulations is often difficult - it needs fast patrol boats to be constantly on watch. Reserves set up and run by local people can provide a better solution.

*Mariculture*, or farming of sea creatures can help in the conservation of living reef species. Giant clams, lobsters, anemonefish and other species have all been successfully cultivated.

*Rare or vulnerable reef species* are protected by law in some countries. International trade in marine turtles, giant clams, black corals and reef corals is monitored and controlled through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).



## The Marine Conservation Society 'Let Coral Reef Live Campaign'

MCS recognises the international importance of coral reefs and is working to protect them through its *Let Coral Reefs Live Campaign*. We aim to:

- increase public awareness of reef conservation issues
- reduce impacts caused by trade in reef species
- undertake practical reef conservation projects overseas

### Public awareness

MCS produces many articles about reefs and their conservation, and provides information on reef conservation issues to a wide range of people and organisations. In 1991 MCS launched a 'Visitor's Code' leaflet which is being distributed by tour operators and displayed at dive centres overseas. Reef conservation displays are being prepared for public places such as libraries and marine life centres.

### Trade in reef animals and plants

*Living specimens for marine aquaria*  
MCS has produced a comprehensive report on conservation aspects of the tropical marine aquarium trade which includes recommendations on management. It is now investigating the possibility of introducing an "eco-labelling" scheme for exotic marine species as part of a continuing programme to bring about improvements in the marine aquatic trade.

### Corals, shells and other curios

MCS published a report on marine curios in 1988 and in 1989 successfully lobbied for tighter controls on international trade in corals. A leaflet aimed at the buying public ('Tempted to Buy Marine Souvenirs: Please Don't') has been produced and widely circulated in the UK and overseas.

Following surveys of outlets selling marine curios, the Society published a booklet entitled *The Marine Curio*

*Trade: Conservation Guidelines and Legislation*, (1991) which is being distributed mainly to traders in the UK. The Society worked closely with HM Customs and Excise during recent seizures of illegally imported corals, and will continue to campaign for better controls and more effective monitoring throughout the curio trade.

### Reef conservation overseas

MCS has links with many people involved in reef conservation work overseas and its publication and leaflets are widely requested.

MCS is running a coral reef educational project in the Turks and Caicos Islands (British West Indies), and is developing other projects, including a programme of reef research in the British Indian Ocean Territory.

### What you can do to help

Although coral reefs do not occur around Britain, many people are alarmed at the damage being inflicted upon them. There are several ways that you can help:-

- Support the MCS *Let Coral Reefs Live Campaign*. MCS is the only voluntary organisation in the UK with people working specifically to protect coral reefs. Funds are urgently required. Join the Society and send a donation for the coral reef campaign.
- Help minimise trade in reef life. Reef animals are collected live from the wild to be sold dead, as souvenirs. You can help by resisting the temptation to buy them, particularly corals (the building blocks of the reef), and any shells or other animals advertised as rare.
- Treat coral reefs with respect. If you go snorkelling and diving on reefs take great care. Corals are living animals and are damaged even by gentle handling. Please don't hold on to them, rest on them or kick them.

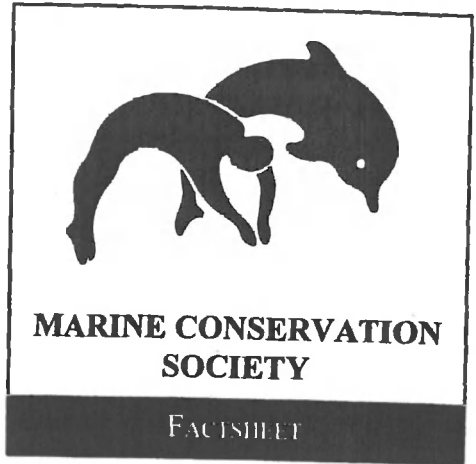


Illustrations c Bob Foster-Smith

## FACTSHEET

*In the UK we have three Marine Nature Reserves, legally protecting the marine environment below low water mark. There are also many voluntary initiatives.*

# MARINE PROTECTED AREAS (MPAs)



## WHY IS THE SEA DIFFERENT?

Nature reserves on land are a familiar sight - they range from those which are strictly controlled to protect a rare species or habitat to local nature reserves, which are a focus for the community and play an important educational role. Terrestrial nature reserves might be owned/leased and/or managed by the country conservation agencies (English Nature, Countryside Council for Wales, Scottish Natural Heritage), voluntary conservation organisations such as Wildlife Trusts or the RSPB, local authorities or private land-owners. So, why is the sea so different?

The key word is 'ownership'. We could manage our gardens for wildlife conservation if we wish, providing we own or lease the land, but ownership of the sea is extremely complex. A conservation organisation cannot buy a bit of sea to manage as a nature reserve as it could on land. Coastal land owners own down to high water mark with a few exceptions who own the shore to low water mark. Beyond that, the Crown Estate has ownership over the sea bed within territorial waters (12 nautical miles). Although organisations such as the Ministry of Agriculture, Fisheries

and Food (fisheries agreements), Sea Fisheries Committees (fisheries by-laws), the Environment Agency (water quality) and the Department of Trade and Industry (offshore oil and gas licensing) have specific jurisdiction over the sea, no-one

'owns' the water and the sea is traditionally perceived as a 'free-for-all'. Despite this and the general lack of knowledge and concern for life below the waves (out of sight out of mind), we do have marine nature reserves in the U.K.

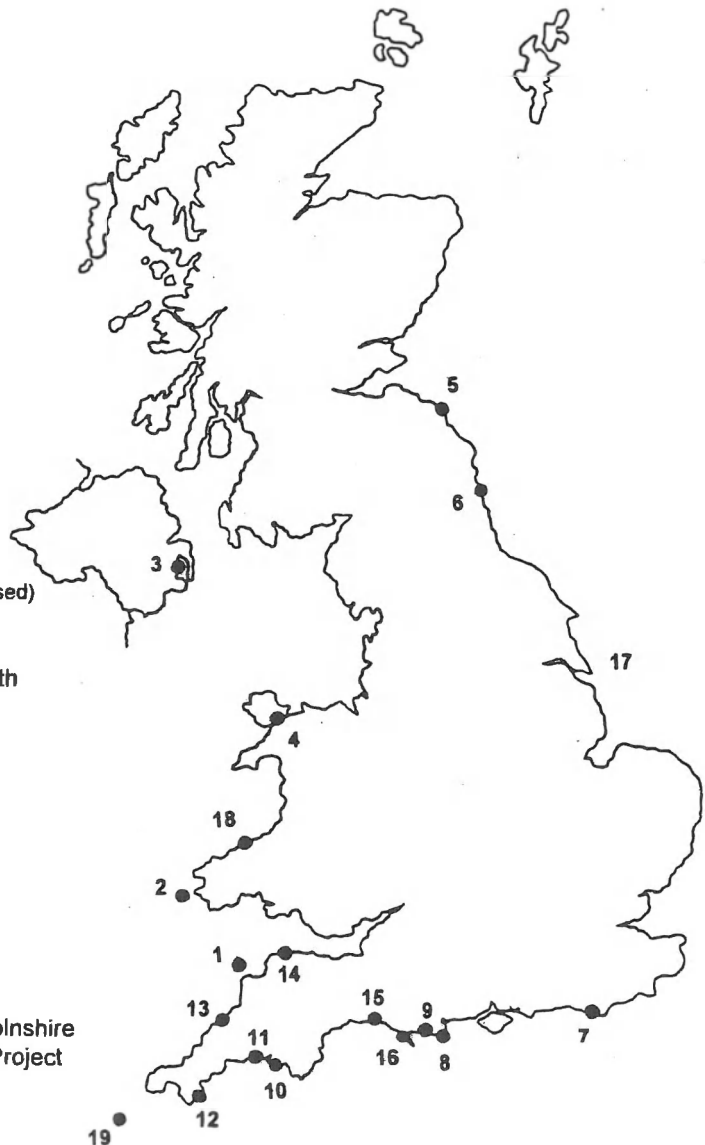
### KEY:

#### MPAs

- 1 Lundy
- 2 Skomer
- 3 Strangford Lough
- 4 Menai Strait (proposed)

#### Voluntary MPAs

- 5 St Abbs & Eyemouth
- 6 St Mary's Island
- 7 Seven Sisters
- 8 Durlston
- 9 Purbeck
- 10 Wembury
- 11 Looe
- 12 Helford
- 13 Polzeath
- 14 North Devon
- 15 Charmouth
- 16 Chesil Beach
- 17 Yorkshire & Lincolnshire Coastal Wildlife Project
- 18 Ceredigion
- 19 Isles of Scilly



## THE STATUTORY APPROACH

The Wildlife and Countryside Act (1981) provided legislation to enable designation of Marine Nature Reserves below low water mark. Considerable difficulty has been experienced by the country conservation agencies (English Nature, Countryside Council for Wales and Scottish Natural Heritage) in the designation of Marine Nature Reserves owing to inadequate legislation. In several cases, serious objection by users could not be overcome - perhaps the perception of the sea as a 'free for all' in this country is to blame. To date we have 3 Marine Nature Reserves in the U.K.:

**LUNDY** is a small island in the Bristol Channel. The sea around the Island is designated as a Marine Nature Reserve (since 1986) because it is a special place for wildlife, due to a rare combination of features resulting from the clear waters which are warmed by currents from the Atlantic and the south. The warm water allows exotic animals such as solitary corals and sea fans to flourish alongside more familiar species. The varied light conditions and exposure to waves and currents result in an incredible variety of marine life. The reserve is jointly managed by English Nature, The Landmark Trust and the Devon Sea Fisheries Committee. A zoning scheme for activities in the Reserve was introduced in 1994.

Contact: The Warden, Lundy Island, Bristol Channel, Devon EK39 2LY  
Tel. 01237 431831

**SKOMER**, an island off the West Coast of Wales, is itself a National Nature Reserve, designated in 1990. Over a quarter of a million seabirds nest on its cliffs and clifftops each year. The wave and tide swept seas, seabed and shore around the island and the Marloes Peninsula make up Wales' first Marine Nature Reserve. The reserve, managed by the Countryside Council for Wales, is one of the most important seal breeding sites in south-west Britain and boasts a wide variety of marine habitats, supporting many different plants and animals including rarities such as the carpet coral.  
Contact: Countryside Council for Wales, The Fisherman's Cottage, Martin's Haven, Marloes, Haverfordwest, Dyfed

**STRANGFORD LOUGH** in Northern Ireland was the most recently designated Marine Nature Reserve (1995) and is managed by the Department of the Environment for Northern Ireland. The Lough is a large marine inlet connected to the Irish Sea by the Strangford Narrows. It is famous for its outstanding marine life, waterfowl and other seabirds and seals. Management measures aim to conserve the special features of the Lough and to further the sustainable use of its resources for the continuing benefit and enjoyment of the people of Northern Ireland. Contact: Department of the Environment for Northern Ireland, Calvert House, 23 Castle Place, Belfast BT1 1FY

**THE MENAI STRAIT** in North Wales is a proposed Marine Nature Reserve which is undergoing thorough consultation.

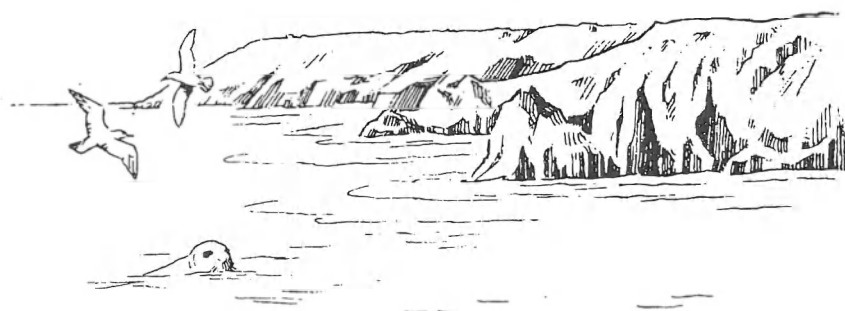
Contact: Countryside Council for Wales, Plas Penrhos, Fford Penrhos, Bangor, Gwynedd LL57 2LQ  
Tel. 01248 370444

The establishment of any further Marine Nature Reserves is unlikely in the next few years, as the country conservation agencies will be striving to meet their obligations to comply with the requirements of the 1992 EEC Council Directive on Conservation of Natural Habitats and of Wild Fauna and Flora (the Habitats and Species Directive) in the designation of marine Special Areas of Conservation (SACs).

## THE VOLUNTARY APPROACH

Before there was any legislation for nature reserves below low water mark, voluntary marine conservation areas (VMCAs), an initiative coming from the local community, were beginning to be established. The islands of Lundy and Skomer were successful voluntary marine reserves before they became statutory. With no legislation to back up these voluntary initiatives (the only controls which can be applied are existing local authority by-laws and the control of access by the land owner), these areas rely on voluntary co-operation to achieve their aims. This co-operative approach has proved to be the greatest strength of these areas as users are drawn in to help with the management of 'their' VMCA - a true 'grass roots' community project.

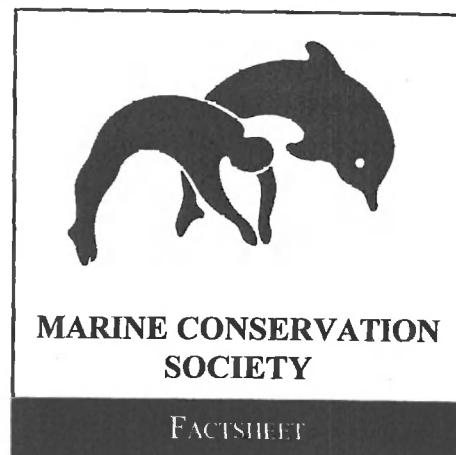
In recent years, several long established VMCAs have taken on a 'new look' with the input of funding from English Nature in voluntary initiatives, recognising that such areas have an important role to play in marine protection a



## FACTSHEET

*Our marine environments are protected to differing degrees by a system of designations and definitions.*

## MARINE PROTECTED AREAS APPENDIX DESIGNATIONS AND DEFINITIONS



Most of us today are familiar with the idea that you can set aside areas that need special protection. This has resulted in certain important areas of land being marked out; National Parks, National Nature Reserves (NNRs) and Sites of Special Scientific Interest (SSSIs) are just a few examples. What may be less well known is that the idea has also been used for nature conservation at sea. As a group, these special areas are known as 'Marine Protected Areas' (MPAs) and have been defined by the International Union for the Conservation of Nature (IUCN) in the following terms:

*Any area of intertidal or [citadel protective] terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment."*

There are many different types of Marine Protected Area (MPA). In UK waters, these include areas set aside for nature conservation, areas given special protection as part of fisheries management (e.g. *Shetland Box*), navigation areas (e.g. *Area to be Avoided, Particularly Sensitive Area, Special Area*) and areas identified to protect underwater sites

of archaeological importance (*Protected Wreck Site*).

Whilst all of these have some benefit to nature conservation, this Appendix concentrates on those areas which were set up specifically for nature conservation.

### AREAS OF SPECIAL INTEREST - STATUTORY DESIGNATIONS

#### Sites of Special Scientific Interest (SSSIs)

Where terrestrial locations have special examples of wildlife or geological features, the Country Agencies (English Nature, Countryside Council for Wales and Scottish Natural Heritage) can designate them Sites of Special Scientific Interest (SSSIs). They provide help and guidance to owners or managers in protecting the nature conservation value of their land. There are intertidal SSSIs but this designation does not extend below low water mark.

#### Marine Nature Reserves (MNRs)

The Government included new powers under the 1981 Wildlife and Countryside Act to legally designate Marine Nature Reserves (MNRs). Considerable difficulty has been experienced by the Country Agencies (English Nature,

Countryside Council for Wales and Scottish Natural Heritage) in the designation of Marine Nature Reserves owing to inadequate legislation. In several cases, serious objection by users could not be overcome - perhaps the perception of the sea as a 'free for all' in this country is to blame. To date we have three Marine Nature Reserves in the UK: the seas around Lundy Island in the Bristol Channel, Skomer Island off the South West coast of Wales and Strangford Lough in Northern Ireland. The Menai Strait in North Wales is a proposed MNR undergoing consultation. (For further details see MPAs factsheet.)

The 1992 EEC Council Directive on Conservation of Natural Habitats and of Wild Fauna and Flora (*The Habitats & Species Directive*) is European law which provides for the creation of a network of protected areas across the European Union to be known as "Natura 2000". The network will consist of **Special Areas of Conservation (SACs)**, designated under the Habitats Directive and **Special Protection Areas (SPAs)**, designated under the *Birds Directive*. The Directive also requires Member States to set up an effective system to prevent the capture, killing, injuring or damaging disturbance of certain endangered species.

The Directive includes categories of marine and tidal habitats e.g. estuaries, lagoons, shallow inlets and bays, citadel sandbanks, reefs and sea caves and species such as the Bottlenose Dolphin and the Common Seal. We will not see designation of SACs until the turn of the century.

#### **MANAGING MARINE WILDLIFE AREAS - VOLUNTARY DEFINITIONS**

Statutory mechanisms, such as MNRs or SACs may take many years to achieve the protection of citadel areas because of the lengthy consultation procedures. The Country Agencies recognise that although they are committed to these designations, in the short and medium term and whilst improvements to statutory processes are sought, alternative mechanisms are needed.

#### **Marine Consultation Areas (Scotland only)**

These are areas considered to be of 'particular distinction in respect of the quality and sensitivity of their marine environment' - 29 sites, to date, are given this status. All of them are in Scotland and they were introduced as a way of ensuring that Scottish Natural Heritage was consulted over proposals for marine fish farms in Scottish sea lochs.

#### **Sensitive Marine Areas (England only)**

As a result of information obtained from the Marine Nature Conservation Review and survey work carried out by voluntary organisations, English Nature identified 27 areas, based on their important plant and animal communities and/or ecological support to adjacent statutory sites. The areas are in close proximity to human populations, or subject to some appreciable human use. **Flamborough Head Sensitive**

Marine Area has been a successful pilot.

#### **Marine Sites of Nature Conservation Importance (MSNCIs)**

On land, Local Authorities, agencies and Wildlife Trusts have identified over 500 SNCIs to give some protection to their habitats and wildlife and to encourage sensitive management. The *Seasearch* project and other survey work has shown that equally valuable habitats occur below low water mark and that some are of importance in a regional or even national context. By extending the SNCI network into the marine realm, the intention is to raise awareness of these citadel sites and ensure that the special interest is preserved in the future. A number of sites have been identified as the initial MSNCIs off Sussex.

Contact: West Sussex County Planning Department (Ecology Section) Tel: 01243 752052  
East Sussex County Planning Department (Ecology Section) Tel: 01273 481621

#### **Voluntary Marine Conservation Areas (VMCAs)**

There are a number of excellent VMCAs in the U.K. and other voluntary marine initiatives. These are local community projects and act as a focus for marine education, interpretation and research. For details of VMCAs see MPAs Factsheet.

Many **Heritage Coasts** in England and Wales are addressing marine issues. In West Wales, the Ceredigion Marine Heritage Coast gives the marine environment special emphasis. For more information on Heritage Coasts contact CoastNET, Tel: 0161 247 1067, or Countryside Commission, Tel: 01242 521381 and Countryside Council for Wales, Tel: 01248 370444

**Estuary and Firth Management Initiatives** are involving relevant organisations and the community in management plan preparation and implementation.

Contact: English Nature, Northminster House, Peterborough  
Tel: 01733 340345  
Scottish Natural Heritage, Andersen Place, Edinburgh EH6 5NP Tel: 0131 5549797

#### **THE WIDER SEA**

##### **Natural Areas (England)**

To help achieve its aim to encourage sustainable use of the wider sea and work to influence users and regulators to accept a duty of care for nature conservation, English Nature has defined 23 Natural Areas in the marine environment. Covering the whole coast of England, these areas are based on natural processes rather than administrative boundaries and extend out to 12 miles.

Contact: English Nature, Northminster House, Peterborough  
Tel: 01733 340345

As you can see, there are a confusing number of designations and definitions (mostly voluntary), all aiming to protect the marine environment for wildlife and future generations. The Marine Conservation Society encourages and supports these initiatives and is encouraged by the opportunity for marine site protection provided by the Habitats and Species Directive. The Marine Conservation Society would like to see an effective system of legally protected Marine Protected Areas in the U.K., set in the context of wider coastal zone and sea use management.



from WWF.UK in addition to local funding sources. The Marine Conservation Society has encouraged and supported VMCA's since they were first established, providing guidance for those wishing to establish an area, introducing a wardening scheme in partnership with WWF.UK and Heinz Guardians of the Countryside and providing training and networking opportunities. There have been several exciting, new initiatives in recent years. VMCA's have become a focus for marine education and interpretation on the coast and some have an important research and monitoring role.

## **AROUND THE COAST VMCA FACTS**

**F. T. ABBS AND EYEMOUTH VOLUNTARY MARINE RESERVE** on the south-east coast of Scotland is an extremely popular diving location in addition to supporting an active fishing industry. Its main achievements have included promotion of a 'voluntary divers' code of conduct, various diving projects, underwater photographic competitions, 'arm chair dives' and rock pool rambles. Contact: The Warden, Wellridge, The Bogan, Coldingham, Berwickshire TD14 5ND Tel: 01890 771273

**G. MARY'S ISLAND VOLUNTARY MARINE CONSERVATION AREA**, Tyne and Wear is a small, accessible site attached to the Tyneside suburb of South Shields. The lighthouse and Peper's cottages (visitor centre) contain displays on history including wrecks and natural history. Rock pool rambles are run regularly for the public and visiting school groups. Contact: St Mary's Lighthouse, South Shields, Tyne and Wear NE26 3AS Tel: 0191 2008653

**SEVEN SISTERS VOLUNTARY MARINE CONSERVATION AREA** on the Sussex Coast focuses on rocky shore education and interpretation with programmes of seashore events and the promotion of a seashore code.

Contact: Seven Sisters Country Park, Exceat, Seaford, Sussex Tel: 01323 870280

**DURLSTON MARINE RESEARCH AREA** on the Purbeck Coast in Dorset operates a cetacean recording scheme using local volunteers watching from the clifftop. A fixed hydrophone on the seabed carries out acoustic monitoring, providing information on the area e.g. cetaceans and seismic activity and offering an innovative interpretive tool. A remote-controlled video camera on the cliff face gives visitors and ornithologists alike a close-up view of nesting guillemots.

Contact: Durlston Coastwatch, The Park Centre, Durlston Country Park, Swanage, Dorset Tel: 01292 421111

**PURBECK MARINE WILDLIFE RESERVE**, also on the Purbeck Coast was the first mainland VMCA. It focuses on marine education and interpretation using techniques such as aquaria, a touch pool, plankton exhibit and a seabed video camera, beaming 'real-time' video to the visitor centre. Many educational groups visit the reserve. *Seasearch* surveys are carried out, using volunteer divers. A 'Limpet Protection Zone' on the beach and limpets on a sheet of perspex in the touch pool, which can be turned over and harmlessly examined have appeared to have been successful in reducing disturbance and damage.

Contact: Dorset Wildlife Trust, Brooklands Farm, Forston, Dorchester, Dorset DT2 7AA Tel: 01305 264620

**WEMBURY VOLUNTARY MARINE CONSERVATION AREA** is situated on the South Devon Coast close to Plymouth. Many schools visit during the early summer term and the warden visits schools, guides visits to the shore, leads rockpool rambles etc. A Marine Centre, built in 1994, has interactive 'action stations', a feely box, videos and a 'litter monster'.

Contact: Devon Wildlife Trust, Shirehampton House, 35 -37 St. David's Hill, Exeter, Devon EX4 4DA Tel: 01392 433221

**LOOE VOLUNTARY MARINE CONSERVATION AREA** in Cornwall has no coastal designations but has very varied habitats and attracts large numbers of visitors. It was established as a focus for interpreting the marine environment and to balance the interests of visitors and the local community. A colour leaflet illustrates not only the marine habitats and species found in the area, but also the human impacts. Contact: Project Explore, Discovery Centre, Millpool, West Looe, Cornwall PL13 2AF Tel: 01503 263266

**HELTFORD VOLUNTARY MARINE CONSERVATION AREA** is a small, isolated ria in Cornwall with a wide variety of habitats and species. Uses include oyster farming and fishing. Much survey work is carried out and information provided. Fishermen have become involved.

Contact: Cornish Biological Records Unit, Trevithick Building, Trevenson Road, Pool, Cornwall TR15 3PL

**POLZEATH VOLUNTARY MARINE WILDLIFE AREA** on the north coast of Cornwall was chosen because of the challenges it offered - it is close to the most populated area not the most remote and there is a good variety of marine

species. The approach has been not to protect but to raise awareness. A mobile marine centre was developed and a laminated Seashore Guide and a Teachers' Guide to North Cornwall has been produced.

Contact: North Cornwall Heritage Coast, 3/5 Barn Lane, Bodmin, PL31 1LZ Tel: 01208 261239

**NORTH DEVON VOLUNTARY MARINE AREA** was defined in 1994. The warden works with other centres in the region to promote the area and uses mobile displays and gives presentations. A Schools Programme aims to target all schools in the area. The area is working in partnership with the Devon Wildlife Trust to produce an educational resource pack. A monitoring programme is being developed.

Contact: Council Offices, Northfield Road, Ilfracombe, Devon Tel: 01271 867496

## **OTHER VOLUNTARY INITIATIVES**

The **CHARMOUTH HERITAGE COAST CENTRE** in West Dorset acts as a focus for marine interpretation for the area with 'high tech.' interpretative techniques such as computer-based interactive displays and audio-visual programmes.

Contact: Charmouth HC Centre, Lower Sea Lane, Charmouth, Dorset, DT6 6LL Tel: 0 1297 560772

The **CHESIL BEACH CENTRE**, also in West Dorset, focuses on the Fleet Lagoon and Chesil Bank, internationally important for bird life but recognising the importance of marine life in the food web. This is an interesting area in management terms as the bed of the Fleet is privately owned.

Contact: The Chesil Beach Centre, Portland Beach Road, Portland, Dorset DT4 9XE Tel. 01305 760579

**THE YORKSHIRE AND LINCOLNSHIRE COASTAL WILDLIFE PROJECT** is run jointly by the Lincolnshire and Yorkshire Wildlife Trusts - a co-operative approach to managing this stretch of North Sea sedimentary coastline including the Humber Estuary. The Project aims to evaluate the natural resources and assess threats and conflicts of interest, raise awareness, set a nature conservation agenda for shoreline management plans, flood defence strategies and other non-statutory plans and strategies and promote community involvement.

Contact: Institute of Estuarine/Coastal Studies, University of Hull, Hull, North Humberside Tel: 01482 465667

Another interesting approach to voluntary protection is the **CEREDIGION MARINE HERITAGE COAST**. Although the Marine Conservation Society believes that all Heritage Coasts should include the 'wet bit', it is all too easy to neglect it in favour of terrestrial obligations. The definition of a separate Marine Heritage Coast in West Wales ensures that this does not happen and awareness events and boat trips are held regularly.

Contact: Ceredigion Marine Heritage Coast, Planning Dept., Aberaeron, Pembrokeshire SA46 0AT Tel: 01545 570881

**ISLES OF SCILLY MARINE PARK** was set up as a result of local demand in November 1989. It was a substitute for the proposed Marine Nature Reserve, which was perceived as a threat by fishermen. It is run by the Isles of Scilly Environment Trust in co-operation with the Duchy of Cornwall.

Contact: Isles of Scilly Marine Park, Isles of Scilly Environment Trust, St Mary's, Isles of Scilly.

**Harbour Projects** such as **Padstow** and **Fowey** are practising voluntary conservation management.

## **WORKING TOGETHER**

Those involved with the running of both statutory and voluntary marine reserves are networking to ensure that experiences are shared and that 'wheels are not reinvented'. VMCA's in Dorset and Cornwall are working together to link their activities, establish joint projects and opportunities for promotion through Coastlink groups.

The Marine Conservation Society believes that there is an important role for both statutory and voluntary reserves in an effective system of marine protected areas in the U.K. and has actively encouraged and supported voluntary initiatives and campaigned for effective statutory protection for the marine environment. For details of other definitions and designations see appendix to this factsheet entitled *Designations and Definitions*.

## **WHAT YOU CAN DO TO HELP:**

- ❖ **Contact your local VMNR (details above) to ask about how you can help, or contact Sarah Welton, MCS Education Officer, on 01929 471562 for information on setting up a new reserve.**
- ❖ **Join the Marine Conservation Society and support our campaigns to protect the marine environment for wildlife and future generations:**

### **Marine Conservation Society**

9 Gloucester Road  
Ross-on-Wye  
Herefordshire HR9 5BU  
Tel 01989 566017  
Fax 01989 567815



**Marine Conservation Society**

**Marine Conservation Society Ltd**

Registered Charity No 1004005

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**Fax 01989/567815**

**E-mail [info@mcsuk.org](mailto:info@mcsuk.org)**

**Web site [www.mcsuk.org](http://www.mcsuk.org)**

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry, no matter how small, should be recorded to ensure the integrity of the financial statements. This includes not only sales and purchases but also expenses, income, and transfers.

The second part of the document provides a detailed breakdown of the accounting process. It starts with the identification of the accounting cycle, which consists of eight steps: identifying the accounting cycle, analyzing and journalizing the transactions, posting to the ledger, determining debits and credits, preparing a trial balance, adjusting the entries, preparing financial statements, and closing the books.

The third part of the document focuses on the preparation of financial statements. It explains how the trial balance is used to verify the accuracy of the accounting records and how it serves as the basis for preparing the income statement, balance sheet, and statement of cash flows.

The fourth part of the document discusses the importance of internal controls. It outlines various measures that can be implemented to prevent errors and fraud, such as segregation of duties, authorization of transactions, and regular audits.

The fifth part of the document provides a summary of the key concepts and principles discussed throughout the document. It reiterates the importance of accuracy, transparency, and adherence to accounting standards.